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EXECUTIVE DIGITAL COMPUTER PROGRAM FOR PRELIMINARY DESIGN OF WASTEWATER TREATMENT SYSTEMS

Richard G. Eilers, et al

Federal Water Quality Administration

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DIGITAL COMPUTER PROGRAM
FOR
PRELIMINARY DESIGN OF WASTEWATER TREATMENT SYSTEMS

By
Richard G. Eilers
Robert Smith

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16. Abstracts

This computer program (FORTRAN, IBM 1130) can be used to compute the quasi-steady-state performance and cost of groups of conventional and advanced wastewater treatment unit processes arranged in any configuration. Each subroutine computes the performance and cost of a single unit process. An influent stream vector and decision variables are input. The program presently contains subroutines for simulating the following wastewater treatment processes: preliminary treatment, primary sedimentation, aeration-final sedimentation, trickling filtration-final sedimentation, chlorination, anaerobic sludge digestion, vacuum filtration, gravity sludge thickening, sludge elutriation, sludge drying beds, stream mixer, and stream splitter.

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*Sewage treatment
*Sanitary engineering
*Computerized simulation
Cost engineering

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*Wastewater treatment plants
Treatment plant design
Unit process models

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INTRODUCTION

A digital computer program which can be used to compute the quasi-steady-state performance and cost of groups of conventional and advanced wastewater treatment processes arranged in any configuration has been developed at the Advanced Waste Treatment Research Laboratory of the Federal Water Quality Administration, United States Department of the Interior. This program is written in FORTRAN and is designed to run on a 16K IBM 1130 computer. The Executive program presently contains a main program and 12 process subroutines; each subroutine computes the performance and cost of a single wastewater treatment process. Two additional subroutines are provided. The first, entitled COST, sums the costs of the individual processes, adds engineering cost, contractor's profit, contingencies and omissions, and cost of land. The second subroutine entitled PRINT simply prints all pertinent data in a format which is described later in the section of this report entitled PRINTED OUTPUT FORMAT. The 12 processes presently included in the program together with the subroutine names are listed below:

PROCESS NAME	SUBROUTINE NAME
Preliminary Treatment	PREL
Primary Settler	PRSET
Aerator-Final Settler	AERFS
Trickling Filter-Final Settler	TRFS
Chlorination	CHLOR
Mixer	MIX
Splitter	SPLIT
Digester	DIG
Vacuum Filter	VACF
Sludge Thickener	THICK
Sludge Elutriation	ELUT
Sludge Drying Beds	SBEDS

Sample input cases, definitions of the FORTRAN variables, a listing of the entire FORTRAN program, a sample printout, and coding forms designed for preparing input to the program are all included in the APPENDIX to this report

Federal Water Quality Administration sponsored work is now underway to provide subroutines for additional wastewater treatment processes. Subroutines for the following processes will be added to the program as they become available:

1. Final Clarifier for the Activated Sludge Process
2. Fluidized Bed Incineration of Sludges
3. Coagulation and Sedimentation of Secondary Effluent following Lime or Alum Addition
4. Ammonia Stripping of Secondary Effluent
5. Granular Carbon Adsorption
6. Ion Exchange
7. Electrodialysis
8. Reverse Osmosis
9. Influent Pumping Facilities
10. Bar Screen
11. Comminution
12. Grit Removal
13. Flow Measurement
14. Flotation Thickening
15. Plain Aeration
16. Waste Stabilization Ponds
17. Two-Stage Anaerobic Digestion
18. Aerobic Digestion
19. Centrifugation of Organic Sludges
20. Multiple Hearth Incineration
21. Microscreening
22. Rough Filtration
23. Multi-Media Filtration
24. Disinfection
25. Recarbonation Using CO_2

Two additional engineering analysis projects will provide better estimates of construction cost and operating and maintenance cost. Several large measurement programs will supply better empirical design data for secondary processes.

PROGRAM DESCRIPTION

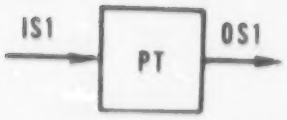
The first step in using the program is to draw the process diagram showing the processes to be used and the connecting and recycle streams. For this purpose, the process symbols shown in FIGURES 1 to 3 are suggested. The process symbols for process subroutines not yet included in the program are also given. Example process diagrams are shown in FIGURE 4. Each process and each stream is assigned a number by the program user. The stream and process numbers that can be used are 1 through 25. The principal influent stream to the system is always assigned the number one (1), and the principal effluent stream from the system is always assigned the number twenty-five (25). The number zero (0) is given to processes involving no cost calculations or decisions (input parameters), such as the mixer or the splitter. Notice that the volume of the split stream must be supplied by some downstream process, such as sludge elutriation.

The program provides for initially reading in the influent and guess streams. For most cases, it is only necessary to supply the influent stream as input. All stream vectors are stored in the stream matrix (SMATX) which has 20 rows and 25 columns. One stream vector is stored in each column of SMATX. A temporary stream matrix (TMATX) with 20 rows and 25 columns is used internally by the program to store newly computed stream vectors until they can be compared with the previously computed values during the program's recycle iterations. The error (EPS) which will be tolerated when recycle streams are involved is also supplied as input to the program. The value for EPS normally used in the program is .10 mg/l. Each stream

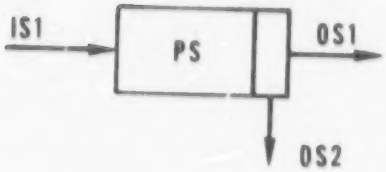
FIGURE 1

PROCESS SYMBOLS

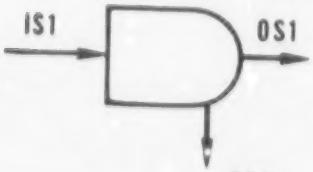
Subroutines for these processes are presently in the program



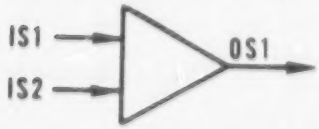
Preliminary Treatment



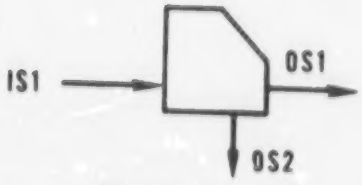
Primary Sedimentation



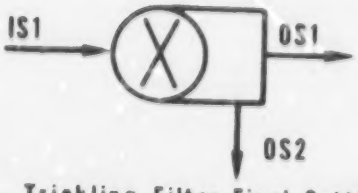
Aerator-Final Settler



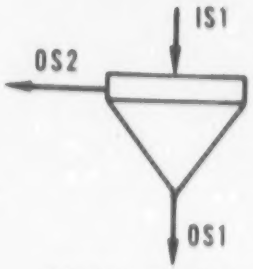
Mixer



Vacuum Filtration

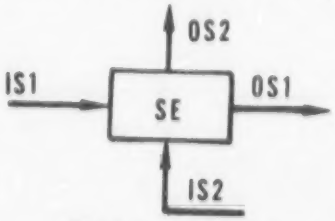


Trickling Filter-Final Settler

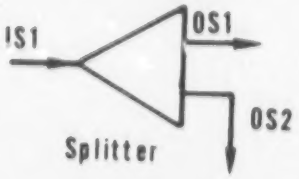


Sludge Thickener

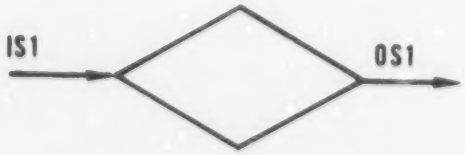
Completely Mixed Anaerobic Digestion



Sludge Elutriation



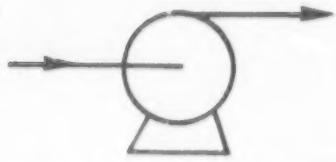
Splitter



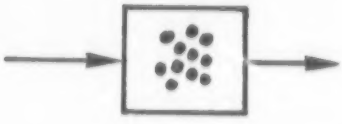
Chlorination

FIGURE 2
PROCESS SYMBOLS

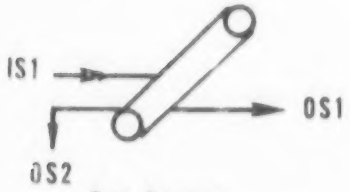
Subroutines for these processes are not presently in the program



Influent Pumping Facilities

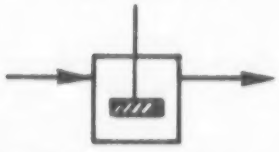


Plain Aeration

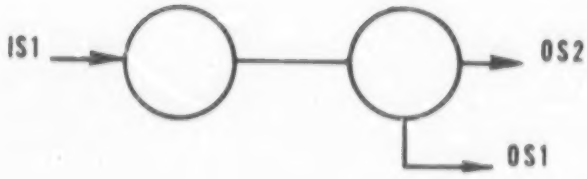


Bar Screen

Waste Stabilization Ponds



Comminution



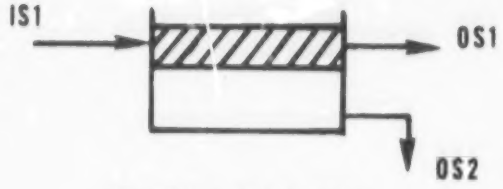
Two Stage Anaerobic Digestion

Grit Removal

Aerobic Digestion

Flow Measurement

Centrifugation of Organic Sludges



Flotation Thickening

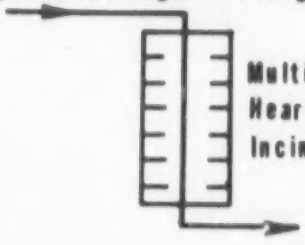
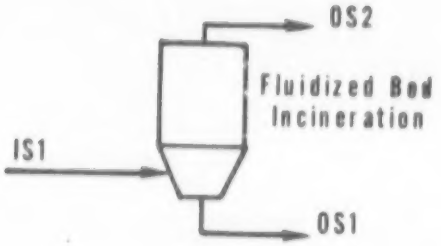
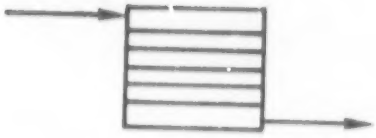


FIGURE 3
PROCESS SYMBOLS

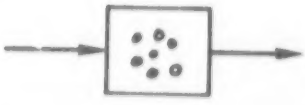
Subroutines for these processes are not presently in the program



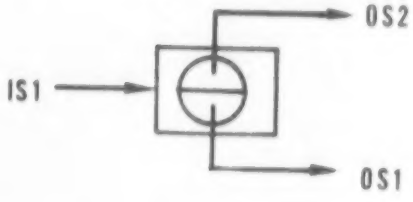
Single Stage Lime Clarification



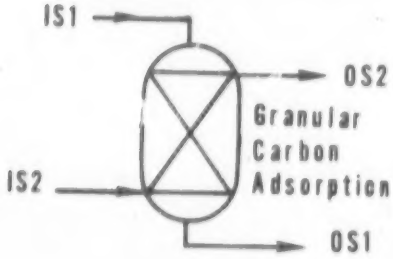
Ammonia Stripping and
Cooling Towers

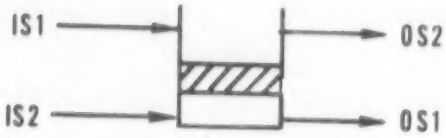


Recarbonation Using CO_2

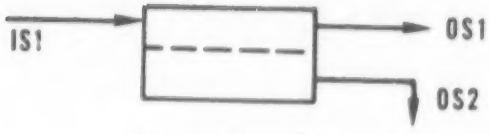


Microscreening

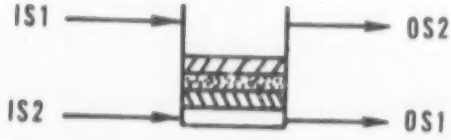




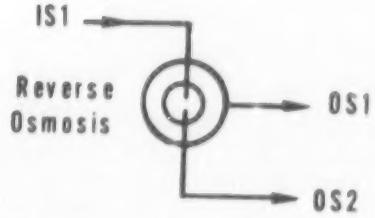
Rough Filtration

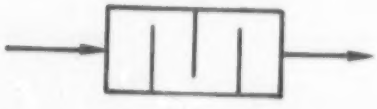


Electrodialysis

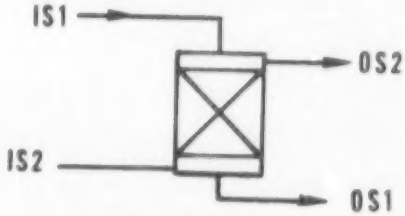


Multi- Media Filtration



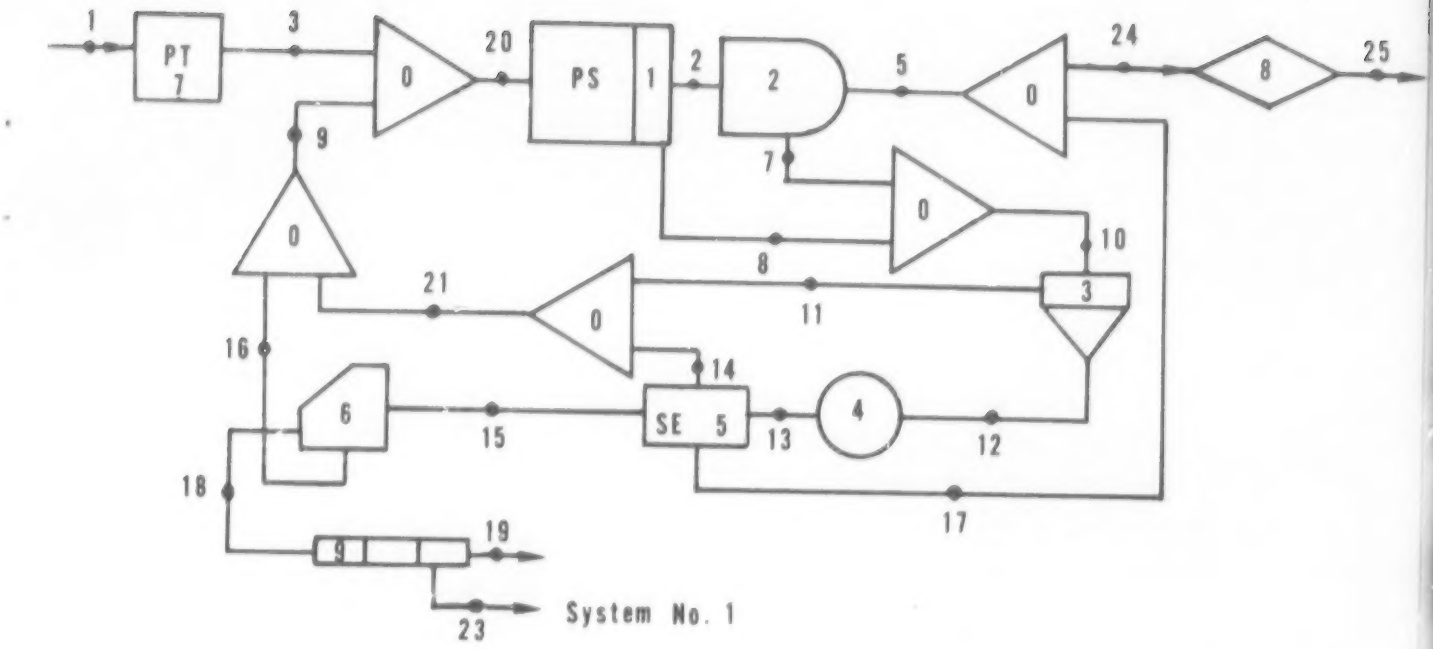


Disinfection

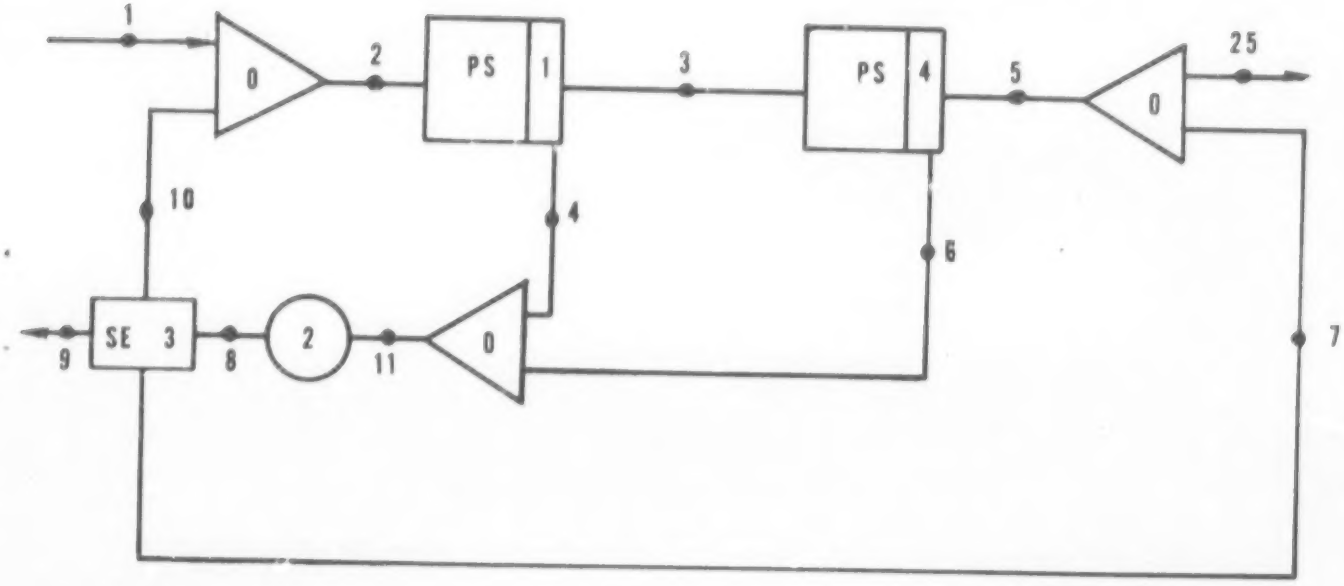


Ion Exchange

FIGURE 4
EXAMPLE PROCESS DIAGRAMS DIAGRAMS



System No. 1



System No. 2

is described by the stream number in the first row of SMATX, the volume flow in million of gallons per day in the second row, and the concentration of 15 contaminants in rows 3-17. Note that the number of contaminants contained in the stream vector will increase as new process subroutines are added to the program. A list of information contained in the stream vector is shown in TABLE 1 with the FORTRAN variable names used.

A decision matrix (DMATX) is provided with 16 rows and 20 columns for storing design parameters such as overflow rates, solids loading rates, or operating mode decisions, such as mixed liquor suspended solids concentration in the aerator or the BOD to be achieved in the principal effluent stream. Decision parameters for the Nth process are stored in the Nth column of DMATX. Column 20 of DMATX is reserved for cost parameters which apply to all processes. Row 16 (or additional rows if required, such as in the AERFS process) of DMATX is reserved for the excess capacity factor (ECF) which is a multiplier on the size of the process to allow for shutdown for cleaning and maintenance. A list of the contents of DMATX is shown in TABLE 2. For processes having a non-zero process number (N), the contents of the Nth column of DMATX are read into the program from 2 cards which follow the process card for the Nth process. For the mixer and splitter no process number is assigned, or the number zero is given, and the 2 cards containing decision parameters are omitted for these processes.

An output matrix (OMATX) is provided with 20 rows and 20 columns for storing computed output parameters (to be later printed out) from the various process subroutines. Output parameters for the Nth process

TABLE 1

CONTENTS OF STREAM MATRIX (SMATX)

(I designates the stream number)

Row No.	Descriptive Parameters	FORTRAN Variable Names
1	Stream Number	SMATX(1,I), I
2	Volume Flow, mgd	SMATX(2,I), Q
3	Solid Organic Carbon, mg/l	SMATX(3,I), SOC
4	Solid Nonbiodegradable Carbon, mg/l	SMATX(4,I), SNBC
5	Solid Organic Nitrogen, mg/l	SMATX(5,I), SON
6	Solid Organic Phosphorus, mg/l	SMATX(6,I), SOP
7	Solid Fixed Matter, mg/l	SMATX(7,I), SFM
8	Solid BOD, mg/l	SMATX(8,I), SBOD
9	Volatile Suspended Solids, mg/l	SMATX(9,I), VSS
10	Total Suspended Solids, mg/l	SMATX(10,I), TSS
11	Dissolved Organic Carbon, mg/l	SMATX(11,I), DOC
12	Dissolved Nonbiodegradable Carbon, mg/l	SMATX(12,I), DNBC
13	Dissolved Nitrogen, mg/l	SMATX(13,I), DN
14	Dissolved Phosphorus, mg/l	SMATX(14,I), DP
15	Dissolved Fixed Matter, mg/l	SMATX(15,I), DFM
16	Alkalinity, mg/l	SMATX(16,I), ALK
17	Dissolved BOD, mg/l	SMATX(17,I), DBOD
18	Unassigned	
19	Unassigned	
20	Unassigned	

TABLE 2

CONTENTS OF DECISION MATRIX (DMATX)

(N designates the process number)

Aerator-Final Settler

DMATX(1,N) = BOD of OS1
DMATX(2,N) = XMLSS
DMATX(3,N) = DEGC
DMATX(4,N) = CAER20
DMATX(5,N) = DO
DMATX(6,N) = AEFF20
DMATX(7,N) = URSS
DMATX(8,N) = GSS
DMATX(13,N) = ECF (Final Settler)
DMATX(14,N) = ECF (Sludge Return Pump)
DMATX(15,N) = ECF (Blowers)
DMATX(16,N) = ECF (Aerator)

Thickener

DMATX(1,N) = TRR
DMATX(2,N) = TSS of OS1
DMATX(3,N) = GTH
DMATX(4,N) = GSTH
DMATX(16,N) = ECF

Vacuum Filtration

DMATX(1,N) = VFL
DMATX(2,N) = TVF
DMATX(3,N) = TSS
DMATX(16,N) = ECF

Sludge Drying Beds

DMATX(1,N) = SBL
DMATX(16,N) = ECF

Preliminary Treatment

DMATX(16,N) = ECF

Chlorination

DMATX(1,N) = DCL2
DMATX(2,N) = TCL2
DMATX(16,N) = ECF

Primary Settler

DMATX(1,N) = FRPS
DMATX(2,N) = URPS
DMATX(16,N) = ECF

Digester

DMATX(1,N) = TD
DMATX(2,N) = TDIG
DMATX(16,N) = ECF

Elutriation

DMATX(1,N) = ERR
DMATX(2,N) = TSS of OS1
DMATX(3,N) = WRE
DMATX(4,N) = GE
DMATX(5,N) = GES
DMATX(16,N) = ECF

Cost Constants

DMATX(1,20) = CKWH
DMATX(2,20) = CCI
DMATX(3,20) = AF
DMATX(4,20) = CTRP
DMATX(5,20) = CTGO
DMATX(6,20) = CLAND
DMATX(7,20) = CFECL3
DMATX(8,20) = CCL2

Trickling Filter-Final Settler

DMATX(1,N) = BOD of OS1
DMATX(2,N) = DEGC
DMATX(3,N) = HQ
DMATX(4,N) = SAREA
DMATX(5,N) = URSS
DMATX(6,N) = XRSS
DMATX(7,N) = RECYCL
DMATX(8,N) = GSS
DMATX(14,N) = ECF (Pumps)
DMATX(15,N) = ECF (Final Settler)
DMATX(16,N) = ECF (Filter)

are stored in the Nth column of OMATX. Column 20 of OMATX is reserved for output cost parameters which apply to all processes. A list of the contents of OMATX is shown in TABLE 3.

The calling or main program is entitled MAIN and has the function of calling the process subroutines for computing the performance and cost of individual processes in the proper order. When recycle loops occur, this involves recomputing all of the processes within the recycle loop in an iterative manner until each element of all stream vectors involved ceases to vary by more than the prescribed tolerance (EPS).

A description of the system configuration, that is, the processes to be used and the location of the interconnecting streams is communicated to the computer by an input deck of process cards. One card is used for each process. The process number (N) is punched in columns 3 and 4 as shown on the sample coding forms in the APPENDIX. The type of process is specified by an assigned identification number. The process subroutine names and identification numbers are listed below:

SUBROUTINE NAME	IDENTIFICATION NUMBER
PREL	1
PRSET	2
AERFS	3
MIX	4
SPLIT	5
DIG	6
VACF	7
THICK	8
ELUT	9
SBEDS	10
TRFS	11
CHLOR	12

TABLE 3

CONTENTS OF OUTPUT MATRIX (OMATX)

(N designates the process number)

Aerator-Final Settler

OMATX(1,N) = BOD2
OMATX(2,N) = DOSAT
OMATX(3,N) = XRSS
OMATX(4,N) = AFS
OMATX(5,N) = CAER
OMATX(6,N) = CEDR
OMATX(7,N) = VAER
OMATX(8,N) = VNIT
OMATX(9,N) = XMLAS
OMATX(10,N) = XMLBS
OMATX(11,N) = XMLNB
OMATX(12,N) = XMLDS
OMATX(13,N) = XMLIS
OMATX(14,N) = FOOD
OMATX(15,N) = RTURN
OMATX(16,N) = CNIT
OMATX(17,N) = CKWH
OMATX(18,N) = ARCFD
OMATX(19,N) = BSIZE
OMATX(20,N) = CFPGL

Primary Settler

OMATX(1,N) = GPS
OMATX(2,N) = APS

Thickener

OMATX(1,N) = ATHM

Digester

OMATX(1,N) = C1DIG
OMATX(2,N) = C2DIG
OMATX(3,N) = VDIG
OMATX(4,N) = CH4
OMATX(5,N) = CO2

Vacuum Filter

OMATX(1,N) = CFCL3
OMATX(2,N) = FECL3
OMATX(3,N) = WP
OMATX(4,N) = AVF
OMATX(5,N) = CCHEM

Elutriation

OMATX(1,N) = AE

Sludge Drying Beds

OMATX(1,N) = ASB

Trickling Filter-Final Settler

OMATX(1,N) = AFS
OMATX(2,N) = VOL
OMATX(3,N) = FAREA
OMATX(4,N) = DEPTH

Chlorination

OMATX(1,N) = CCL2

Cost

OMATX(1,20) = CENG
OMATX(2,20) = CCR
OMATX(3,20) = TCAP
OMATX(4,20) = TAMM
OMATX(5,20) = TOPER
OMATX(6,20) = TOTAL

The identification number of the type of process is punched in columns 7 and 8 of the process card. If desired, the process subroutine name can be punched in columns 10-16 in order to clearly identify the process card and to include this information in the final program printout. The number of the principal input stream to the process (IS1) is punched in columns 20 and 21. If a second input stream exists, the number of the stream (IS2) is punched in columns 30 and 31. The principal output stream from the process (OS1) is punched in columns 40 and 41. If a second output stream exists, the number (OS2) is punched in columns 50 and 51. Notice that the principal input and output streams must correspond to the designation shown in FIGURES 1 to 3.

The order in which the processes are computed is determined by the integer (K) punched in column 1 and the integer (III) punched in column 80. K is the recycle loop number and it can be assigned any number from 1 to 9. Note that when K is set equal to 9, this signifies an end-of-file for input to a particular case. The first and last processes to be computed in a recycle loop are marked with the same loop number (K) in column 1. Recycle loops within recycle loops are allowed, but each loop must be assigned a unique loop number.

The integer (III) is used to identify primary loops, that is, loops which are not inside of any other loop. The first and last process of primary loops are marked by the integer (1) in column 80, all the other processes within the primary loop have the integer (0) punched in column 80. Processes which are not part of any recycle loop are marked with the integer (2) in column 80.

A list of the process cards are printed as part of the output format of the program. The process cards for the two systems shown in FIGURE 4 are listed in TABLE 4.

TABLE 4

INPUT DATA System No. 1

K	N	PROCESS	IS1	IS2	OS1	OS2	III
0	7	1 PREL	1	0	3	0	2
1	0	4 MIX	3	9	20	0	1
0	1	2 PRSET	20	0	2	8	0
0	2	3 AERFS	2	0	5	7	0
0	0	5 SPLIT	5	0	24	17	0
0	0	4 MIX	7	8	10	0	0
0	3	8 THICK	10	0	12	11	0
0	4	6 DIG	12	0	13	0	0
0	5	9 ELUT	13	17	15	14	0
0	6	7 VACF	15	0	18	16	0
0	0	4 MIX	11	14	21	0	0
1	0	4 MIX	16	21	9	0	1
0	8	12 CHLOR	24	0	25	0	2
0	9	10 SBEDS	18	0	19	0	2
9	0	0	0	0	0	0	0

INPUT DATA System No. 2

K	N	PROCESS	IS1	IS2	OS1	OS2	III
1	0	4 MIX	1	10	2	0	1
2	0	4 MIX	1	10	2	0	0
0	1	2 PRSET	2	0	3	4	0
0	0	4 MIX	4	6	11	0	0
0	2	6 DIG	11	0	8	0	0
2	3	9 ELUT	8	7	9	10	0
0	0	5 SPLIT	5	0	25	7	0
1	4	2 PRSET	3	0	5	6	1
9	0	0	0	0	0	0	0

USE OF CODING FORMS

Two coding forms have been developed for preparing input data to the program. These are found in FIGURE V of the APPENDIX. SHEET 1 contains the description of the influent and guess streams. The number of streams read in cannot exceed ten. The number of input streams (NIS) to be read is punched in the first four columns of the first input card. The stream numbers are then read in (in the order that they will appear) as elements of the NN vector. The flow and concentrations of the first, second, third, etc., streams are then read in using F10.3 fields. The tolerance (EPS) to be used for recycle iteration is read in with a F10.3 field on the first card.

The next group of data to be read in on SHEET 1 contains general cost information. These data are read into column 20 of the decision matrix (DMATX). Definitions of these terms can be found in FIGURE II of the APPENDIX.

Process cards are prepared next on SHEET 2 with the two decision cards following each process card unless the process number is zero. The parameters shown on the decision cards will correspond to the process specified on the process card; see TABLE 2. After one process card and two decision cards (where necessary) have been prepared for each process in the system and they have been arranged in the correct order, the input deck is terminated with a card in which a (9) has been punched in the first column. This card is important because it indicates end-of-file.

PRINTED OUTPUT FORMAT

Sample output from the program is given in FIGURE IV of the APPENDIX. The first group of output printing shows the process cards which describe the wastewater treatment system which was simulated. The second group of data shows the volume flow and concentrations of 15 contaminants in each numbered stream. The stream is identified by the letter (S) followed by the stream number in the left-hand column of the printout. For example, stream number 3 is identified by (S 3).

The third set of output lists the processes according to process number and gives the name of the process with all pertinent parameters relating to the process. The process is identified by the letter (P) followed by the process number in the left-hand column of the printout. For example, process number 3 is identified by (P 3). The capital cost for the process is given in thousands of dollars. The operating and maintenance cost, the amortization cost, and the total treatment cost are given for each process in cents per thousand gallons of water treated. The flow used here is always that of the influent stream designated as stream number 1. The fourth set of printout shows the general cost items, such as the capital cost index (CCI), the amortization factor (AF), the cost of engineering (CENG), contractor's profit (CTRP), contingencies and omissions (CTGO), and land (CLAND). The total capital cost of the entire system is given in thousands of dollars. The total amortization cost, total operating and maintenance cost, and total treatment cost for the system are given in cents per 1000 gallons of water treated.

Detailed discussion of individual process models can be found in the following FWQA Report No. WP-20-9:

Preliminary Design and Simulation of Conventional Wastewater Renovation Systems Using the Digital Computer

by

Robert Smith

The trickling filter model is fully described in the following FWQA Report No. W69-2:

A Mathematical Model for a Trickling Filter

by

Joseph F. Roesler
Robert Smith

APPENDIX

INPUT DATA FOR THE EXECUTIVE PROGRAM

Input Card 1: FORMAT(I2)
NCASE

Input Card 2: FORMAT(11I4,6X,F10.3)
NIS,(NN(I),I=1,10),EPS

Input Cards 3, 4 (or more): FORMAT(8F10.3/8F10.3)
(SMATX(I,NN(1)),I=2,17)

Input Cards 5, 6, 7: FORMAT(8F10.3/8F10.3)
(DMATX(I,20),I=1,16)

Input Card 8: FORMAT(I1,1X, ,1X,3A2,4X,I2,8X,I2,8X,I2,8X,I2,
28X,
K,N,IPROC, ,1,3),IS1,IS2,OS1,OS2,III

Input Cards 9, 10, 11: FORMAT(8F10.3/8F10.3)
(DMATX(I,N),I=1,16)

Input Cards 12 and on: Continue with additional process cards.
Process card with a (9) punched in column (1) will indicate end of case.
Begin next data case with Input Card 2, etc.

FIGURE I gives the card input for the two sample systems of FIGURE 4 in the text.

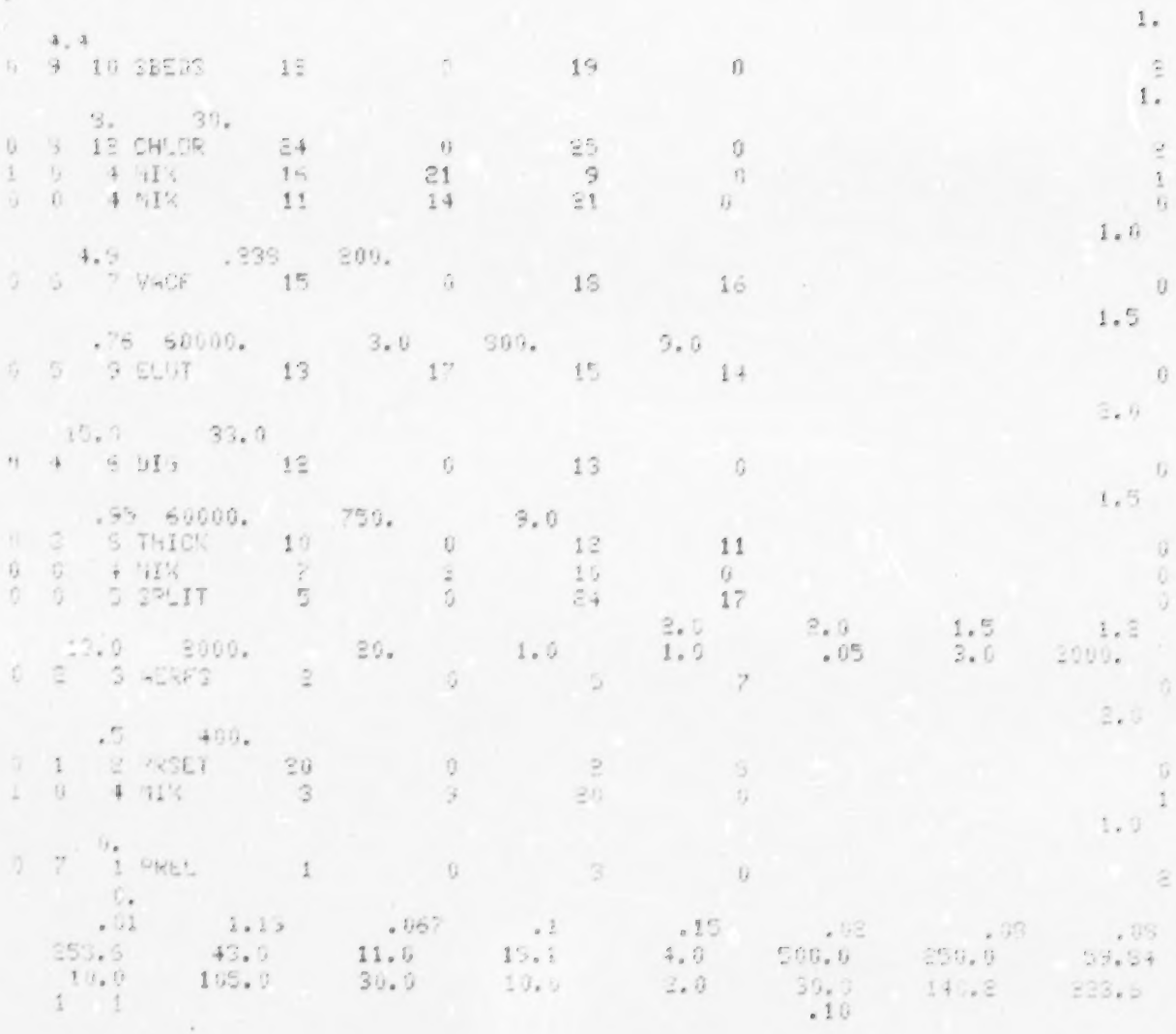
FIGURE II gives the definitions of the FORTRAN variables used by the EXECUTIVE program.

FIGURE III gives the entire FORTRAN listing of the EXECUTIVE program.

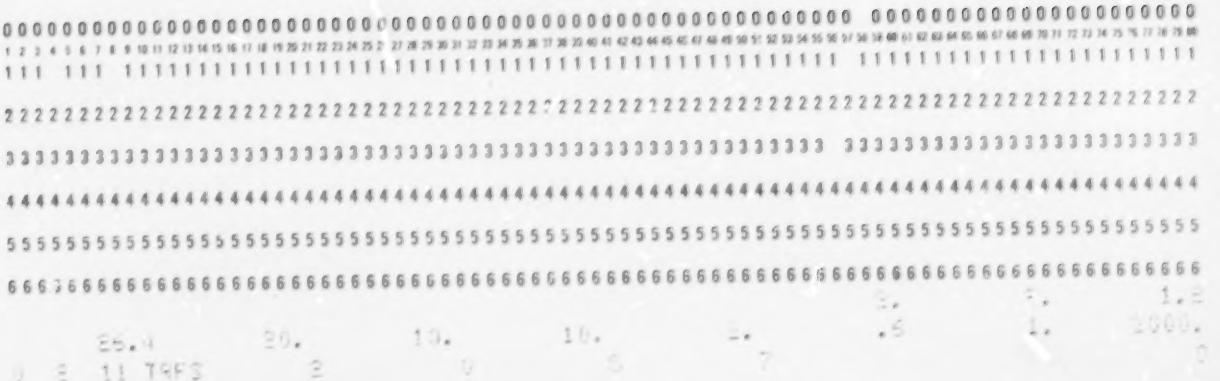
FIGURE IV gives the program printout for System No. 1 of FIGURE 4 in the text.

FIGURE V gives the two coding forms that can be used to prepare input for the EXECUTIVE program.

FIGURE I



System No. 2



Sample Trickling Filter Input Which Could be Used to Replace the Aeration Process in System No. 1

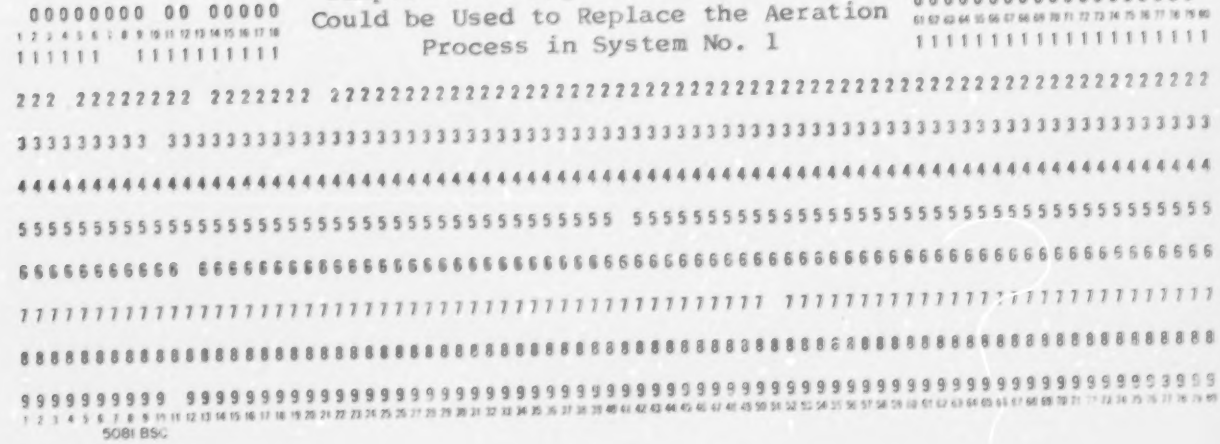


FIGURE II

DEFINITIONS OF FORTRAN SYMBOLS

Computer Symbol	Definitions and Comments
ACOST(I,J)	Amortization cost for the Ith process, cents per 1000 gallons
AE	Surface area of the elutriation tank, sq ft
AEFF20	Efficiency of diffusers in aerator at zero dissolved oxygen and 20°C
AF	Amortization factor
AFS	Surface area of the final settler, sq ft/1000
ARCFD	Air requirements for the aerator, scf/day
ALK	Concentration of alkalinity as $CaCO_3$, mg/l
APS	Surface area of the primary settler, sq ft/1000
ASB	Area of the sludge drying beds, sq ft
ATHM	Greater of the surface area of the thickener based on overflow rate or on solids loading rate, sq ft
AVF	Area of the vacuum filter, sq ft
BOD	Input value for the demand value of 5-day BOD in the final effluent from the aeration or trickling filter process, mg/l
BOD2	Influent 5-day BOD to the aeration process, mg/l
BSIZE	Required size of blower for supplying air to the aerator, cubic feet per minute
C1DIG	Rate constant for digester
C2DIG	Rate constant for digester
CAER	Rate constant for sizing the aerator corrected for water temperature
CAER20	Rate constant used for sizing the aerator when water temperature is 20°C

Computer Symbol	Definitions and Comments
CCHEM	Cost of ferric chloride, dollars per year
CCI	Capital cost index to account for the variation of construction cost with time
CCL2	Cost of chlorine, dollars per pound
CCOST(I,J)	Capital cost for the Ith process, thousands of dollars
CCR	Capital cost ratio: CCR = 1 + CENG + CTRP + CLAND + CTGO
CEDR	Rate at which active solids are destroyed by natural causes in the aerator, fraction per day mass
CENG	Cost of engineering services expressed as a fraction of the total capital cost
CFECL3	Cost of ferric chloride, cents per pound
CRPGL	Air requirement for the aerator, scf/gallon of sewage entering the system
CH4	Standard cubic feet of methane produced in the digester each day, scf/day methane
CKWH	Cost of electrical power, dollars per kilowatt-hour
CLAND	Cost of land expressed as a fraction of the total capital cost
CNIT	Rate constant used in the nitrification calculation
CO2	Standard cubic feet of carbon dioxide produced in the digester each day, scf/day CO_2
COSTO(I,J)	Operating and maintenance cost for the Ith process, cents per 1000 gallons
CTGO	Cost of contingencies and omissions expressed as a fraction of the total capital cost
CTRP	Contractor's profit expressed as a fraction of the total capital cost

Computer Symbol	Definitions and Comments
DBOD	Dissolved BOD concentration, mg/l
DCL2	Dose of chlorine, mg/l
DEGC	Water temperature, degrees centigrade
DEPTH	Depth of the trickling filter, feet
DFM	Dissolved inorganic species, mg/l
DMATX(I,J)	Decision matrix vector for the Jth process
DN	Dissolved nitrogen concentration, mg/l nitrogen
DNBC	Dissolved non-biodegradable carbon concentration, mg/l carbon
DO	Concentration of dissolved oxygen in the aerator, mg/l oxygen
DOC	Dissolved organic carbon concentration, mg/l carbon
DOSAT	Saturation value for dissolved oxygen in the aerator at one-half the water depth, mg/l oxygen
DP	Dissolved phosphorus concentration, mg/l phosphorus
ECF	Excess capacity factor
EPS	Iteration tolerance for recycling systems
ERR	Solids recovery ratio for elutriation
FAERA	Area of the face of the filter, sq ft
FECL3	Concentration of ferric chloride used for sludge conditioning, mg/l $FeCl_3$
FOOD	5-day BOD synthesized to active solids in the aerator each day, mg/l oxygen
FRPS	Fraction of solids entering the primary settler which is removed from the main stream and sent to the thickener

Computer Symbol	Definitions and Comments
GE	Design overflow rate for elutriation, gallons per day per sq ft
GES	Design solids loading rate for elutriation, lb/day/sq ft
GPS	Computed overflow rate for the primary settler, gpd/sq ft
GSS	Design overflow rate for the final settler, gpd/sq ft
GSTH	Design solids loading rate for the thickener, lb/day/sq ft
GTH	Design overflow rate for the thickener, gpd/sq ft
HQ	Trickling filter hydraulic loading, mgd/acre
III	Integer input to the program that controls the recycling in the system
IPROC	Integer input to the program that is used to identify the type of process
IS1	Input stream number 1 to a process
IS2	Input stream number 2 to a process
K	Integer input to the program that controls the recycling in the system
N	Process number assigned to a particular process in the system by the program user
NAME(I)	Integer input vector that is used to print process names as part of the final output
NCASE	Integer input to the program that specifies the number of cases to be executed by the program
NIS	Integer input to the program that specifies the number of influent and guess streams to be read by the program

Computer Symbol	Definitions and Comments
NN(I)	Integer inputs to the program that specify the stream numbers of the influent and guess streams to be read by the program
OMATX(I,J)	Output matrix vector for the Jth process
OS1	Output stream number 1 from a process
OS2	Output stream number 2 from a process
Q	Volume flow, mgd
RECYCL	Trickling filter recirculation number
RTURN	Sludge return ratio for the aerator
SAREA	Trickling filter specific surface area, feet squared per feet cubed
SBOD	Solid 5-day BOD concentration, mg/l oxygen
SBL	Sludge bed loading, pounds of solids/ft^2 of bed area/month
SFM	Solid inorganic matter concentration, mg/l mass
SMATX(I,J)	Stream matrix vector for the Jth stream
SNBC	Solid non-biodegradable carbon concentration, mg/l carbon
SOC	Solid carbon concentration, mg/l carbon
SON	Solid nitrogen concentration, mg/l nitrogen
SOP	Solid phosphorus concentration, mg/l phosphorus
TAMM	Total amortization cost for the entire system, cents per 1000 gallons
TCAP	Total capital cost for the entire system, thousands of dollars
TCL2	Chlorine contact time, minutes
TCOST(I,J)	Total treatment cost for the Ith process, cents per 1000 gallons

Computer Symbol	Definitions and Comments
TD	Digester detention time, days
TDIG	Sludge temperature in digester, degrees centigrade
TMATX(I,J)	Temporary stream matrix vector for the Jth stream that is used internally by the program for the recycling iteration
TOPER	Total operating and maintenance cost for the entire system, cents per 1000 gallons
TOTAL	Total treatment cost for the entire system, cents per 1000 gallons
TRR	Solids recovery ratio for thickening
TSS	Total suspended solids concentration, mg/l mass
TVF	Fraction of the time vacuum filters are operated
URPS	Ratio of solids concentration in OS2 from the primary settler to the solids concentration in IS1 to the primary settler
URSS	Ratio of solids concentration in OS2 (underflow stream) from the aerator-final settler to the total solids concentration in the aerator
VAER	Volume of the aerator, millions of gallons
VDIG	Volume of the digester, cubic feet/1000
VFL	Vacuum filter loading, gallons per hour per sq ft
VOL	Trickling filter total volume, cubic feet
VNIT	Volume of the aerator required to achieve nitrification, millions of gallons
VSS	Volatile suspended solids concentration, mg/l mass
WP	Percentage of moisture in the filtered sludge

Computer Symbol	Definitions and Comments
WRE	Wash water ratio for elutriation
XMLAS (MLASS)	Concentration of active solids held in the aerator, mg/l mass
XMLBS (MLBSS)	Concentration of unmetabolized biodegradable solids held in the aerator, mg/l mass
XMLDS (MLDSS)	Concentration of non-biodegradable solids in the aerator caused by destruction of active solids by natural causes, mg/l mass
XMLIS (MLISS)	Concentration of inert inorganic solids in the aerator caused by inorganic solids in the influent stream, mg/l mass
XMLNB (MLNBSS)	Concentration of non-biodegradable organic solids in the aerator, mg/l mass
XMLSS (MLSS)	Total concentration of solids in the aerator, mg/l mass
XRSS	Ratio of solids concentration of OS1 (overflow stream from the aerator-final settler to the total solids concentration in the aerator

mgd = millions of gallons per day
mg/l = milligrams per liter
scf = standard cubic feet
gpd = gallons per day

FIGURE III

EXECUTIVE PROGRAM FOR PRELIMINARY DESIGN

```
      INTEGER OS1,OS2
      DIMENSION IFAIL(10),LCOP(10),NN(10),NAME(3)
      COMMON SMATX(20,25),TMATX(20,25),DMATX(20,20),OMATX(20,20),IP(25),
     . INP,IO,IS1,IS2,OS1,OS2,N,IAERF,CCOST(20,5),COSTO(20,5),
     . ACOST(20,5),TCOST(20,5)
      DEFINE FILE 10 (50,15,U,NNNNN)
      INP=2
      IO=5
      READ(INP,1) NCASE
    1 FORMAT(I2)
      DO 1120 IJ=1,NCASE
      DO 5 I=1,20
      DO 5 J=1,25
      SMATX(I,J)=0.
    5 TMATX(I,J)=0.
      DO 10 I=1,20
      DO 10 J=1,20
      DMATX(I,J)=0.
   10 OMATX(I,J)=0.
      DO 15 I=1,20
      DO 15 J=1,5
      CCOST(I,J)=0.
      COSTO(I,J)=0.
      ACOST(I,J)=0.
   15 TCOST(I,J)=0.
      DO 16 I=1,25
   16 IP(I)=0
      DO 17 I=1,10
      IFAIL(I)=0
      LCOP(I)=0
   17 NN(I)=0
      IAERF=0
      KKK=1
      READ(INP,20) NIS,(NN(I),I=1,10),EPS
   20 FORMAT(11I4,5X,F10.3)
      DO 40 J=1,NIS
      LL=NN(J)
   40 READ(INP,60) (SMATX(I,LL),I=2,17)
   60 FORMAT(8F10.3/8F10.3)
      READ(INP,60) (DMATX(I,20),I=1,16)
      WRITE(IO,80)
   80 FORMAT(1H1,////,55X,'INPUT DATA',//,25X,'K',5X,'N',5X,'PROCESS',
     . 9X,'IS1',7X,'IS2',7X,'CS1',7X,'OS2',7X,'III',//)
  100 READ(INP,120) K,N,IPROC,(NAME(I),I=1,3),IS1,IS2,OS1,OS2,III
  120 FORMAT(I1,1X,I2,2X,I2,1X,3A2,4X,I2,8X,I2,8X,I2,8X,I2,28X,I1)
      WRITE(IO,140) K,N,IPROC,(NAME(I),I=1,3),IS1,IS2,OS1,OS2,III
  140 FORMAT(25X,I1,4X,I2,4X,I2,2X,3A2,7X,I2,8X,I2,8X,I2,8X,I2,8X,I2)
      IF(K-9) 160,280,160
  160 SMATX(1,IS1)=IS1
      SMATX(1,OS1)=OS1
      IF(IS2) 180,200,180
  180 SMATX(1,IS2)=IS2
  200 IF(OS2) 220,240,220
  220 SMATX(1,OS2)=OS2
  240 IF(N) 260,280,260
  260 IP(N)=IPROC
      READ(INP,60) (DMATX(I,N),I=1,16)
```

```
280 WRITE(10'KKK) K,N,IPROC,IS1,IS2,OS1,OS2,III
    KKK=KKK+1
    IF(K-9) 100,300,100
300 KKK=1
    K=0
    INDC=0
    IN=1
320 IFLUK=0
340 IFAIL(IN)=0
    KOUT=0
360 READ(10'KKK) K,N,IPROC,IS1,IS2,OS1,OS2,III
    KKK=KKK+1
    IF(K-9) 380,1110,380
380 IF(K) 390,420,390
390 IF(INDC) 420,400,420
400 INDC=K
420 IF(K) 440,500,440
440 IF(K-INDC) 460,500,460
460 LOOP(IN)=INDC
    IN=IN+1
    INDC=K
    KOUT=0
    IF(IFLUK-1) 480,500,480
480 IFLUK=IFAIL(IN-1)
500 IF(K-INDC) 540,520,540
520 KOUT=KOUT+1
540 GO TO (550,560,570,590,600,610,620,630,640,650,660,670),IPROC
550 CALL PREL
    GO TO 700
560 CALL PRSET
    GO TO 700
570 CALL AERFS
    IF(IAERF) 1120,580,1120
580 GO TO 700
590 CALL MIX
    GO TO 700
600 CALL SPLIT
    GO TO 700
610 CALL DIG
    GO TO 700
620 CALL VACF
    GO TO 700
630 CALL THICK
    GO TO 700
640 CALL ELUT
    GO TO 700
650 CALL SBEDS
    GO TO 700
660 CALL TRFS
    GO TO 700
670 CALL CHLOR
700 IF(III-2) 720,340,720
720 DO 740 I=2,17
    IF(ABS(SMATX(I,OS1)-TMATX(I,OS1))-EPS) 740,740,800
740 CONTINUE
    IF(OS2) 760,820,760
760 DO 780 I=2,17
```

```
      IF(ABS(SMATX(I,OS2)-TMATX(I,OS2))-EPS) 780,780,800
  780 CONTINUE
      GO TO 820
  800 IFAIL(IN)=1
  820 DO 840 I=1,20
  840 TMATX(I,OS1)=SMATX(I,OS1)
      IF(OS2) 860,900,860
  860 DO 880 I=1,20
  880 TMATX(I,OS2)=SMATX(I,OS2)
  900 IF(KOUT-2) 360,920,360
  920 IF(IFAIL(IN)) 980,940,980
  940 IF(IFLUK) 980,960,980
  960 IF(III-1) 980,1080,980
  980 IF(IFAIL(IN)) 1000,1060,1000
 1000 KKK=1
 1020 READ(10'KKK) K,N,IPROC,IS1,IS2,OS1,OS2,III
      KKK=KKK+1
      IF(K-INDC) 1020,1040,1020
 1040 KKK=KKK-1
      IF(III-1) 340,320,340
 1060 INDC=LOOP(IN-1)
      KOUT=1
      IN=IN-1
      GO TO 360
 1080 INDC=0
      GO TO 320
 1110 CALL COST
      CALL PRINT
 1120 CONTINUE
      CALL EXIT
      END
```

```
      SUBROUTINE PREL
      INTEGER OS1,OS2
      COMMON SMATX(20,25),TMATX(20,25),DMATX(20,20),OMATX(20,20),IP(25),
     . INP,IO,IS1,IS2,OS1,OS2,N,IAERF,CCOST(20,5),COSTO(20,5),
     . ACOST(20,5),TCOST(20,5)
      DO 10 I=2,17
   10 SMATX(I,OS1)=SMATX(I,IS1)
      Q1=SMATX(2,IS1)*DMATX(16,N)
      CCOST(N,1)=14.7*Q1**.625
      COSTO(N,1)=.5*Q1+2.15*Q1**.37
      RETURN
      END
```

PRIMARY SETTLER

```
      SUBROUTINE PRSET
      INTEGER OS1,OS2
      COMMON SMATX(20,25),TMATX(20,25),DMATX(20,20),OMATX(20,20),IP(25),
     . INP,IO,IS1,IS2,OS1,OS2,N,IAERF,CCOST(20,5),COSTO(20,5),
     . ACOST(20,5),TCOST(20,5)
      SMATX(2,OS2)=DMATX(1,N)*SMATX(2,IS1)/DMATX(2,N)
      SMATX(2,OS1)=SMATX(2,IS1)-SMATX(2,OS2)
      TEMP1=(1.-DMATX(1,N))*SMATX(2,IS1)/SMATX(2,OS1)
      TEMP2=DMATX(1,N)*SMATX(2,IS1)/SMATX(2,OS2)
      DO 10 I=3,10
      SMATX(I,OS1)=TEMP1*SMATX(I,IS1)
   10 SMATX(I,OS2)=TEMP2*SMATX(I,IS1)
      DO 20 I=11,17
      SMATX(I,OS2)=SMATX(I,IS1)
   20 SMATX(I,OS1)=SMATX(I,OS2)
      GPS=-2780.*ALOG(DMATX(1,N))-551.7
      APS=SMATX(2,IS1)*1000./GPS*DMATX(16,N)
      CCOST(N,1)=13.4*APS+5.2*APS**.1
      COSTO(N,1)=APS+2.5*APS**.5
      OMATX(1,N)=GPS
      OMATX(2,N)=APS
      RETURN
      END
```

```
      SUBROUTINE AERFS
      INTEGER OS1,OS2
      COMMON SMATX(20,25),TMATX(20,25),DMATX(20,20),OMATX(20,20),IP(25),
     . INP,IO,IS1,IS2,OS1,OS2,N,IAERF,CCOST(20,5),COSTC(20,5),
     . ACOST(20,5),TCOST(20,5)
      BOD2=SMATX(8,IS1)+SMATX(17,IS1)
      DBOD2=SMATX(17,IS1)
      CEDR=.18*1.047**(DMATX(3,N)-28.)
      CAER=DMATX(4,N)*1.047**(DMATX(3,N)-20.)
      SA=DMATX(2,N)/1000.
      TA=(BOD2-DMATX(1,N))/(DMATX(1,N)*CAER*SA*24.)
      VAER=SMATX(2,IS1)*TA
      XRSS=556.1*DMATX(8,N)**.4942/DMATX(2,N)**1.8165/(TA*24.)**.4386
      ASMAX=DMATX(1,N)/XRSS/.685
      ASMIN=0.
      IF(ASMAX-DMATX(2,N)) 20,20,10
   10 ASMAX=DMATX(2,N)
   20 XMLAS=(ASMAX+ASMIN)/2.
      FOOD=SMATX(8,IS1)+DBOD2
      FMAX=FOOD
      N1=1
      GO TO 80
   30 ERROR=FMAX-FMIN
      IF(ERROR-.1) 220,220,40
   40 FOOD=(FMAX+FMIN)/2.
   50 IF(FOOD-SMATX(17,IS1)) 60,60,70
   60 DBOD4=SMATX(17,IS1)-FOOD
      SBOD4=SMATX(8,IS1)
      GO TO 80
   70 SBOD4=(SMATX(8,IS1)+SMATX(17,IS1)-FOOD)*.7
      DBOD4=.233*SBOD4
   80 TEMP1=.65*FOOD/XMLAS-XRSS
      SMATX(2,OS2)=(SMATX(2,IS1)*TEMP1-CEDR*VAER)/(DMATX(7,N)-XRSS)
      SMATX(2,OS1)=SMATX(2,IS1)-SMATX(2,OS2)
      N1=N1+1
      IF(N1-2) 100,100,90
   90 TEMP2=XRSS*SMATX(2,OS1)+DMATX(7,N)*SMATX(2,OS2)
      XMLBS=SMATX(2,IS1)*SBOD4/TEMP2/.8
      SMATX(8,OS1)=(XMLAS*.685+XMLBS*.8)*XRSS
      SMATX(17,OS1)=DBOD4
      TBOD5=SMATX(8,OS1)+SMATX(17,OS1)
      GO TO 110
  100 TBOD5=XMLAS*XRSS*.685
  110 IF(TBOD5-DMATX(1,N)) 120,120,170
  120 IF(N1-3) 130,140,160
  130 FMIN=(CEDR*VAER/SMATX(2,IS1)+XRSS)*XMLAS/.65
      FOOD=FMIN
      GO TO 50
  140 WRITE(IO,150)
  150 FORMAT(10X,'DEMAND MLASS CANNOT BE HELD')
      IAERF=1
      GO TO 370
  160 FMAX=FOOD
      GO TO 30
  170 IF(N1-3) 180,210,200
  180 WRITE(IO,190)
  190 FORMAT(10X,'BOD5 DEMAND CANNOT BE ACHIEVED')
```

```
      IAERF=1
      GO TO 370
  200 FMIN=FOOD
  210 GO TO 30
  220 XMLNB=SMATX(4,IS1)*SMATX(2,IS1)*2.13/TEMP2
      XMLIS=SMATX(2,IS1)*SMATX(7,IS1)/TEMP2
      XMLDS=.12*SMATX(2,IS1)*FOOD/TEMP2-.185*XMLAS
      TEMP3=XMLAS+XMLBS+XMLNB+XMLDS+XMLIS
      TEMP4=TEMP3-DMATX(2,N)
      IF(ABS(TEMP4)-5.) 260,260,230
  230 IF(TEMP4) 240,240,250
  240 ASMIN=XMLAS
      GO TO 20
  250 ASMAX=XMLAS
      GO TO 20
  260 SMATX(3,OS1)=(XMLDS+XMLAS)*XRSS/2.46+(XMLBS+XMLNB)*XRSS/2.33
      SMATX(4,OS1)=XMLNB*XRSS/2.33+(XMLDS+.185*XMLAS)*XRSS/2.46
      TEMP5=XRSS*XMLAS/2.46
      SMATX(5,OS1)=.234*TEMP5+(SMATX(3,OS1)-TEMP5)/10.
      SMATX(6,OS1)=SMATX(3,OS1)*.01
      SMATX(7,OS1)=XMLIS*XRSS
      SMATX(9,OS1)=SMATX(3,OS1)*2.38
      SMATX(10,OS1)=SMATX(7,OS1)+SMATX(9,OS1)
      DO 270 I=3,10
  270 SMATX(I,OS2)=SMATX(I,OS1)*DMATX(7,N)/XRSS
      SMATX(11,OS1)=SMATX(12,IS1)+DBOD4/1.87
      SMATX(12,OS1)=SMATX(12,IS1)
      SMATX(13,OS1)=(SMATX(2,IS1)*(SMATX(5,IS1)+SMATX(13,IS1))-
     . (SMATX(5,OS1)*SMATX(2,OS1)+SMATX(5,OS2)*SMATX(2,OS2)))/
     . (SMATX(2,OS1)+SMATX(2,OS2))
      SMATX(14,OS1)=(SMATX(2,IS1)*(SMATX(6,IS1)+SMATX(14,IS1))-
     . (SMATX(6,OS1)*SMATX(2,OS1)+SMATX(6,OS2)*SMATX(2,OS2)))/
     . (SMATX(2,OS1)+SMATX(2,OS2))
      SMATX(15,OS1)=SMATX(15,IS1)
      DO 280 I=11,15
  280 SMATX(I,OS2)=SMATX(I,OS1)
      Q6=(SMATX(2,IS1)*(1.-.65*FOOD/XMLAS)+CEDR*VAER)/(DMATX(7,N)-1.)
      RTURN=Q6/SMATX(2,IS1)
      X4X3=(1.+RTURN)/RTURN/DMATX(7,N)
      DN3=SMATX(13,IS1)/(1.+RTURN)
      X3Y=DN3*.99/(X4X3-1.)
      CNIT=.18*EXP(.116*(DMATX(3,N)-15.))
      IF(X4X3) 290,290,300
  290 TTAN=0.
      GO TO 310
  300 TTAN=(1.+RTURN)*(ALOG(X4X3)+4.605/(DN3+X3Y))/CNIT
  310 VNIT=SMATX(2,IS1)*TTAN
      IF(VNIT-VAER) 320,320,330
  320 SMATX(16,OS1)=SMATX(16,IS1)+3.57*(SMATX(13,OS1)-SMATX(13,IS1))
      GO TO 340
  330 SMATX(16,OS1)=SMATX(16,IS1)
  340 SMATX(16,OS2)=SMATX(16,OS1)
      SMATX(17,OS2)=SMATX(17,OS1)
      DOSAT=(14.16-.3943*DMATX(3,N)+.007714*DMATX(3,N)**2-.0000646*
     . DMATX(3,N)**3)*1.221
      AEFF=DMATX(6,N)*(DOSAT-DMATX(5,N))*1.02**(DMATX(3,N)-20.)/DOSAT
      WFOOD=SMATX(2,IS1)*FOOD*8.33
```

```
      WAS=XMLAS*VAER*8.33
      ARCFD=(.577*WFOOD+1.16*CEDR*WAS)/AEFF/.232/.075
      WDN=(SMATX(2,OS1)*SMATX(13,OS))+SMATX(2,OS2)*SMATX(13,OS2))*8.33
      IF(VNIT-VAER) 350,350,360
  350 ARCFD=ARCFD+4.6*WDN/AEFF/.232/.075
  360 BSIZE=DMATX(15,N)*ARCFD/1440.
      CFPGL=ARCFD/1000000./SMATX(2,IS1)
      VAER=VAER*DMATX(16,N)
      Q4=Q6+SMATX(2,IS1)
      Q6=Q6*DMATX(14,N)
      AFS=Q4*1000./DMATX(8,N)*DMATX(13,N)
      CAIRP=ARCFD*365.*DMATX(1,20)/1830000.
      CCOST(N,1)=175.*VAER+36.5*VAER**.182
      CCOST(N,2)=10.57+.005857*BSIZE
      CCOST(N,3)=3.65+1.125*Q6
      CCOST(N,4)=12.6*AFS+5.35/AFS**.126
      COSTO(N,1)=10.*VAER+14.5*VAER**.5
      COSTO(N,2)=CAIRP
      COSTO(N,3)=0.
      COSTO(N,4)=0.
      OMATX(1,N)=BOD2
      OMATX(2,N)=DOSAT
      OMATX(3,N)=XRSS
      OMATX(4,N)=AFS
      OMATX(5,N)=CAER
      OMATX(6,N)=CEDR
      OMATX(7,N)=VAER
      OMATX(8,N)=VNIT
      OMATX(9,N)=XMLAS
      OMATX(10,N)=XMLBS
      OMATX(11,N)=XMLNB
      OMATX(12,N)=XMLDS
      OMATX(13,N)=XMLIS
      OMATX(14,N)=FOOD
      OMATX(15,N)=RTURN
      OMATX(16,N)=CNIT
      OMATX(17,N)=DMATX(1,20)
      OMATX(18,N)=ARCFD
      OMATX(19,N)=BSIZE
      OMATX(20,N)=CFPGL
  370 RETURN
      END
```

```
      SUBROUTINE TRFS
      INTEGER OS1,OS2
      COMMON SMATX(20,25),TMATX(20,25),DMATX(20,20),OMATX(20,20),IP(25),
     . INP,IO,IS1,IS2,OS1,OS2,N,IAERF,CCOST(20,5),COSTO(20,5),
     . ACOST(20,5),TCOST(20,5)
      BODIN=SMATX(8,IS1)+SMATX(17,IS1)
      BETA=.0245*1.035**(DMATX(2,N)-20.)
      XN=.91-6.45/DMATX(4,N)
      FAREA=SMATX(2,IS1)/DMATX(3,N)*43560.
      Q6=DMATX(7,N)*SMATX(2,IS1)
      RHQ=((DMATX(7,N)+1.)*DMATX(3,N))**XN
      BOD=(SMATX(17,IS1)+DMATX(6,N)*SMATX(8,IS1))/DMATX(1,N)
      DEPTH=RHQ*ALOG((BOD+DMATX(7,N))/(DMATX(7,N)+1.))/(BETA*DMATX(4,N))
      XPO=EXP(BETA*DMATX(4,N)*DEPTH/RHQ)
      BODO=BODIN/(XPO*(DMATX(7,N)*(1.-1./XPO)+1.))
      DBODO=SMATX(17,IS1)/(XPO*(DMATX(7,N)*(1.-1./XPO)+1.))
      SBOD4=BODO-DBODO
      SBOD5=SBOD4*DMATX(6,N)
      BETAN=.00307*1.141**(DMATX(2,N)-20.)
      XPON=EXP(BETAN*DMATX(4,N)*DEPTH/RHQ)
      SON4=SMATX(5,IS1)*SBOD4/SMATX(8,IS1)
      DN4=(SMATX(13,IS1)+SMATX(5,IS1)-SON4)/(XPON+(XPON-1.)*DMATX(7,N))
      DN5=DN4
      SON5=SON4*DMATX(6,N)
      SMATX(2,OS1)=SMATX(2,IS1)*(1.-DMATX(5,N))/(DMATX(6,N)-DMATX(5,N))
      SMATX(2,OS2)=SMATX(2,IS1)*(1.-DMATX(6,N))/(DMATX(5,N)-DMATX(6,N))
      SMATX(4,OS1)=SMATX(4,IS1)*DMATX(6,N)
      SMATX(4,OS2)=SMATX(4,IS1)*DMATX(5,N)
      SMATX(5,OS1)=SON5
      SMATX(5,OS2)=SON4*DMATX(5,N)
      SMATX(6,OS1)=SMATX(6,IS1)*DMATX(6,N)*SBOD4/SMATX(8,IS1)
      SMATX(6,OS2)=SMATX(6,IS1)*DMATX(5,N)*SBOD4/SMATX(8,IS1)
      SMATX(7,OS1)=SMATX(7,IS1)*DMATX(6,N)
      SMATX(7,OS2)=SMATX(7,IS1)*DMATX(5,N)
      SMATX(8,OS1)=SBOD4*DMATX(6,N)
      SMATX(8,OS2)=SBOD4*DMATX(5,N)
      SMATX(9,OS1)=SBOD4*DMATX(6,N)+SON5+SMATX(4,IS1)*DMATX(6,N)
      SMATX(9,OS2)=SBOD4*DMATX(5,N)+SON4*DMATX(5,N)+SMATX(4,IS1)*
     . DMATX(5,N)
      SMATX(10,OS1)=SMATX(9,OS1)+SMATX(7,OS1)+SMATX(6,OS1)
      SMATX(10,OS2)=SMATX(9,OS2)+SMATX(7,OS2)+SMATX(6,OS2)
      SMATX(12,OS1)=SMATX(12,IS1)
      SMATX(12,OS2)=SMATX(12,IS1)
      SMATX(13,OS1)=DN5
      SMATX(13,OS2)=DN5
      SMATX(14,OS1)=SMATX(14,IS1)+SMATX(6,IS1)*(1.-SBOD4/SMATX(8,IS1))
      SMATX(14,OS2)=SMATX(14,OS1)
      SMATX(15,OS1)=SMATX(15,IS1)
      SMATX(15,OS2)=SMATX(15,IS1)
      SMATX(16,OS1)=SMATX(16,IS1)
      SMATX(16,OS2)=SMATX(16,IS1)
      SMATX(17,OS1)=DBODO
      SMATX(17,OS2)=SMATX(17,OS1)
      SMATX(3,OS1)=(SBOD5+1.87*SMATX(4,OS1))/1.87
      SMATX(3,OS2)=(SMATX(8,OS2)+1.87*SMATX(4,OS2))/1.87
      SMATX(11,OS1)=(DBODO+1.87*SMATX(12,OS1))/1.87
      SMATX(11,OS2)=SMATX(11,OS1)
```

```
      PCR=(BODIN-OMATX(1,N))*100./BODIN
      AFS=SMATX(2,IS1)*1000./OMATX(8,N)*OMATX(15,N)
      VOL=FAREA*DEPTH*OMATX(16,N)
      Q6=Q6*OMATX(14,N)
      IF(OMATX(4,N)-25.) 10,20,20
   10 CCOST(N,1)=4.81*VOL**.907/1000.
      GO TO 30
   20 CCOST(N,1)=25.*VOL**.827/1000.
   30 CCOST(N,2)=(12600.*AFS+5350./AFS**.126)/1000.
      CCOST(N,3)=0.
      COSTO(N,1)=SMATX(2,IS1)*(800.+7200.*(1./SMATX(2,IS1))**.69)/1000.
      COSTO(N,2)=0.
      COSTO(N,3)=0.
      IF(Q6) 50,50,40
   40 CCOST(N,3)=(3650.+1125.*Q6)/1000.
      COSTO(N,3)=.05*CCOST(N,3)+(1911.*Q6*(DEPTH+6.)*OMATX(1,20))/1000.
   50 OMATX(1,N)=AFS
      OMATX(2,N)=VOL
      OMATX(3,N)=FAREA
      OMATX(4,N)=DEPTH
      RETURN
      END
```

STREAM MIXER

```
      SUBROUTINE MIX
      INTEGER OS1,OS2
      COMMON SMATX(20,25),TMATX(20,25),DMATX(20,20),OMATX(20,20),IP(25),
     . INP,IO,IS1,IS2,OS1,OS2,N,IAERF,CCOST(20,5),COSTO(20,5),
     . ACOST(20,5),TCOST(20,5)
      SMATX(2,OS1)=SMATX(2,IS1)+SMATX(2,IS2)
      IF(SMATX(2,OS1)) 10,30,10
   10 TEMP1=SMATX(2,IS1)/(SMATX(2,IS1)+SMATX(2,IS2))
      TEMP2=SMATX(2,IS2)/(SMATX(2,IS1)+SMATX(2,IS2))
      DO 20 I=3,17
   20 SMATX(I,OS1)=TEMP1*SMATX(I,IS1)+TEMP2*SMATX(I,IS2)
   30 RETURN
      END
```

STREAM SPLITTER

```
      SUBROUTINE SPLIT
      INTEGER OS1,OS2
      COMMON SMATX(20,25),TMATX(20,25),DMATX(20,20),OMATX(20,20),IP(25),
     . INP,IO,IS1,IS2,OS1,OS2,N,IAERF,CCOST(20,5),COSTO(20,5),
     . ACOST(20,5),TCOST(20,5)
      SMATX(2,OS1)=SMATX(2,IS1)-SMATX(2,OS2)
      DO 10 I=3,17
      SMATX(I,OS1)=SMATX(I,IS1)
   10 SMATX(I,OS2)=SMATX(I,IS1)
      RETURN
      END
```

```
      SUBROUTINE DIG
      INTEGER OS1,OS2
      COMMON SMATX(20,25),TMATX(20,25),DMATX(20,20),OMATX(20,20),IP(25),
     . INP,IO,IS1,IS2,OS1,OS2,N,IAERF,CCOST(20,5),COSTO(20,5),
     . ACOST(20,5),TCOST(20,5)
      C1DIG=.28/EXP(.036*(35.-DMATX(2,N)))
      C2DIG=700.*EXP(.10*(35.-DMATX(2,N)))
      IF(DMATX(1,N)-10.) 10,10,20
   10 DMATX(1,N)=10.
   20 DIG13=C2DIG/(C1DIG*DMATX(1,N)-1.)
      DIG12=SMATX(3,IS1)-SMATX(4,IS1)+SMATX(11,IS1)-SMATX(12,IS1)
      TEMP1=(DIG12-DIG13)/(SMATX(3,IS1)+SMATX(11,IS1))
      SMATX(2,OS1)=SMATX(2,IS1)
      SMATX(3,OS1)=SMATX(4,IS1)+.75*DIG13
      SMATX(4,OS1)=SMATX(4,IS1)
      SMATX(5,OS1)=(1.-TEMP1)*SMATX(5,IS1)
      SMATX(6,OS1)=(1.-TEMP1)*SMATX(6,IS1)
      SMATX(7,OS1)=SMATX(7,IS1)
      SMATX(8,OS1)=(SMATX(3,OS1)-SMATX(4,OS1))*1.87
      SMATX(9,OS1)=SMATX(3,OS1)*2.38
      SMATX(10,OS1)=SMATX(9,OS1)+SMATX(7,OS1)
      SMATX(11,OS1)=SMATX(12,IS1)+.25*DIG13
      SMATX(12,OS1)=SMATX(12,IS1)
      SMATX(13,OS1)=SMATX(13,IS1)+SMATX(5,IS1)*.65*TEMP1
      SMATX(14,OS1)=SMATX(14,IS1)+TEMP1*SMATX(6,IS1)
      SMATX(15,OS1)=SMATX(15,IS1)
      SMATX(16,OS1)=SMATX(16,IS1)+(SMATX(13,OS1)-SMATX(13,IS1))*3.57
      SMATX(17,OS1)=(SMATX(11,OS1)-SMATX(12,OS1))*1.87
      VDIG=SMATX(2,IS1)*DMATX(1,N)*1000./7.48*DMATX(16,N)
      CH4=163.85*(DIG12-DIG13)*SMATX(2,IS1)
      CO2=249.9*(DIG12-DIG13)*SMATX(2,IS1)-CH4
      CCOST(N,1)=1.04*VDIG+10.7*VDIG**.128
      CCOST(N,2)=5.+.04*VDIG
      COSTO(N,1)=.048*VDIG+.54*VDIG**.44
      OMATX(1,N)=C1DIG
      OMATX(2,N)=C2DIG
      OMATX(3,N)=VDIG
      OMATX(4,N)=CH4
      OMATX(5,N)=CO2
      RETURN
      END
```

VACUUM FILTER

```
      SUBROUTINE VACF
      INTEGER OS1,OS2
      COMMON SMATX(20,25),TMATX(20,25),DMATX(20,20),OMATX(20,20),IP(25),
     . INP,IO,IS1,IS2,OS1,OS2,N,IAERF,CCOST(20,5),COSTO(20,5),
     . ACOST(20,5),TCOST(20,5)
      SMATX(10,OS2)=DMATX(3,N)
      Y1=100.*SMATX(16,IS1)/SMATX(10,IS1)
      Y2=SMATX(9,IS1)/(SMATX(10,IS1)-SMATX(9,IS1))
      FECL3=1.08*Y1+2.*Y2
      WP=88./(SMATX(10,IS1)/10000.)**.123
      TEMP1=1000000.*(100.-WP)/WP
      SMATX(2,OS2)=SMATX(2,IS1)*(TEMP1-SMATX(10,IS1))/(TEMP1-
     . SMATX(10,OS2))
      SMATX(10,OS1)=8.33*(SMATX(2,IS1)*SMATX(10,IS1)-SMATX(2,CS2)*
     . SMATX(10,OS2))
      TEMP2=SMATX(10,OS1)/SMATX(10,IS1)
      TEMP3=SMATX(10,OS2)/SMATX(10,IS1)
      DO 10 I=3,9
      SMATX(I,OS1)=TEMP2*SMATX(I,IS1)
   10 SMATX(I,OS2)=TEMP3*SMATX(I,IS1)
      DO 20 I=11,17
      SMATX(I,OS1)=TEMP2*SMATX(I,IS1)
   20 SMATX(I,OS2)=SMATX(I,IS1)
      AVF=SMATX(2,OS2)*1000000./DMATX(1,N)/DMATX(2,N)/24.*DMATX(16,N)
      CCOST(N,1)=12.8+.372*AVF
      CCHEM=SMATX(10,IS1)*FECL3*SMATX(2,IS1)*30.4*DMATX(7,20)
      COSTO(N,1)=CCHEM/1000.+1.5*SMATX(2,IS1)+6.45*SMATX(2,IS1)**.37
      OMATX(1,N)=DMATX(7,20)
      OMATX(2,N)=FECL3
      OMATX(3,N)=WP
      OMATX(4,N)=AVF
      OMATX(5,N)=CCHEM
      RETURN
      END
```

SLUDGE ELUTRIFICATION

```
      SUBROUTINE ELUT
      INTEGER OS1,OS2
      COMMON SMATX(20,25),TMATX(20,25),DMATX(20,20),OMATX(20,20),IP(25),
     . INP,IO,IS1,IS2,OS1,OS2,N,IAERF,CCOST(20,5),COSTO(20,5),
     . ACOST(20,5),TCOST(20,5)
      SMATX(10,OS1)=DMATX(2,N)
      SMATX(2,IS2)=DMATX(3,N)*SMATX(2,IS1)
      TEMP1=SMATX(2,IS1)*1000000./DMATX(4,N)
      TEMP2=SMATX(2,IS1)*SMATX(10,IS1)*8.33/DMATX(5,N)
      IF(TEMP1-TEMP2) 20,20,10
   10 AE=TEMP1*DMATX(16,N)
      GO TO 30
   20 AE=TEMP2*DMATX(16,N)
   30 SMATX(2,OS1)=DMATX(1,N)*SMATX(2,IS1)*SMATX(10,IS1)/SMATX(10,OS1)
      SMATX(2,OS2)=SMATX(2,IS1)+SMATX(2,IS2)-SMATX(2,OS1)
      SMATX(10,OS2)=SMATX(2,IS1)*((1.-DMATX(1,N))*SMATX(10,IS1)+
     . DMATX(3,N)*SMATX(10,IS2))/SMATX(2,OS2)
      TEMP3=SMATX(10,OS1)/SMATX(10,IS1)
      TEMP4=SMATX(10,OS2)/SMATX(10,IS1)
      DO 40 I=3,9
      SMATX(I,OS1)=TEMP3*SMATX(I,IS1)
   40 SMATX(I,OS2)=TEMP4*SMATX(I,IS2)
      TEMP5=SMATX(2,IS1)/(SMATX(2,IS1)+SMATX(2,IS2))
      TEMP6=SMATX(2,IS2)/(SMATX(2,IS1)+SMATX(2,IS2))
      DO 50 I=11,17
      SMATX(I,OS2)=TEMP5*SMATX(I,IS1)+TEMP6*SMATX(I,IS2)
   50 SMATX(I,OS1)=SMATX(I,OS2)
      CCOST(N,1)=(.0181+.0495/EXP(AE/6000.))*AE
      COSTO(N,1)=0.
      OMATX(1,N)=AE
      RETURN
      END
```

```
      SUBROUTINE THICK
      INTEGER OS1,OS2
      COMMON SMATX(20,25),TMATX(20,25),DMATX(20,20),OMATX(20,20),IP(25),
     . INP,IO,IS1,IS2,OS1,OS2,N,IAERF,CCOST(20,5),COSTO(20,5),
     . ACCST(20,5),TCOST(20,5)
      SMATX(10,OS1)=DMATX(2,N)
      SMATX(2,OS1)=DMATX(1,N)*SMATX(2,IS1)*SMATX(10,IS1)/SMATX(10,OS1)
      SMATX(2,OS2)=SMATX(2,IS1)-SMATX(2,OS1)
      SMATX(10,OS2)=(1.-DMATX(1,N))*SMATX(2,IS1)*SMATX(10,IS1)/
     . SMATX(2,OS2)
      TEMP1=SMATX(10,OS1)/SMATX(10,IS1)
      TEMP2=SMATX(10,OS2)/SMATX(10,IS1)
      DO 10 I=3,9
      SMATX(I,OS1)=TEMP1*SMATX(I,IS1)
   10 SMATX(I,OS2)=TEMP2*SMATX(I,IS1)
      DO 20 I=11,17
      SMATX(I,OS1)=SMATX(I,IS1)
   20 SMATX(I,OS2)=SMATX(I,IS1)
      ATH1=SMATX(2,IS1)*1000000./DMATX(3,N)
      ATH2=SMATX(2,IS1)*SMATX(10,IS1)*8.33/DMATX(4,N)
      IF(ATH1-ATH2) 40,40,30
   30 ATHM=ATH1*DMATX(16,N)
      GO TO 50
   40 ATHM=ATH2*DMATX(16,N)
   50 CCOST(N,1)=(.0181+.00846/EXP(ATHM/13375.))*ATHM
      COSTO(N,1)=0.
      OMATX(1,N)=ATHM
      RETURN
      END
```

SLUDGE DRYING BEDS

```
      SUBROUTINE SBEDS
      INTEGER OS1,OS2
      COMMON SMATX(20,25),TMATX(20,25),DMATX(20,20),OMATX(20,20),IP(25),
     . INP,IO,IS1,IS2,OS1,OS2,N,IAERF,CCOST(20,5),COSTO(20,5),
     . ACOST(20,5),TCOST(20,5)
      ASB=SMATX(10,IS1)*SMATX(2,IS1)*8.33*30./DMATX(1,N)*DMATX(16,N)
      CCOST(N,1)=.0023*ASB
      COSTO(N,1)=0.
      OMATX(1,N)=ASB
      RETURN
      END
```

```
      SUBROUTINE CHLOR
      INTEGER OS1,OS2
      COMMON SMATX(20,25),TMATX(20,25),DMATX(20,20),OMATX(20,20),IP(25),
     . INP,IO,IS1,IS2,OS1,OS2,N,IAERF,CCOST(20,5),COSTO(20,5),
     . ACOST(20,5),TCOST(20,5)
      CCOST(N,1)=(9.*(DMATX(2,N)*SMATX(2,IS1)/15.)**.469)*DMATX(16,N)
      COSTO(N,1)=.001*DMATX(1,N)*SMATX(2,IS1)*8.33*365.*DMATX(8,20)*
     . DMATX(16,N)
      DO 10 I=2,20
   10 SMATX(I,OS1)=SMATX(I,IS1)
      OMATX(1,N)=DMATX(8,20)
      RETURN
      END
```

CALCULATE TOTAL PLANT COSTS

```
      SUBROUTINE COST
      INTEGER OS1,OS2
      COMMON SMATX(20,25),TMATX(20,25),DMATX(20,20),OMATX(20,20),IP(25),
     . INP,IO,IS1,IS2,OS1,OS2,N,IAERF,CCOST(20,5),COSTO(20,5),
     . ACOST(20,5),TCOST(20,5)
      TCAP=0.
      DO 10 J=1,20
      DO 10 I=1,5
      CCOST(J,I)=CCOST(J,I)*DMATX(2,20)
   10 TCAP=TCAP+CCOST(J,I)
      CENG=.08*(1000./TCAP)**.146
      CCR=1.+CENG+DMATX(4,20)+DMATX(5 20)+DMATX(6,20)
      TCAP=TCAP*CCR
      DO 20 J=1,20
      DO 20 I=1,5
   20 CCOST(J,I)=CCOST(J,I)*CCR
      TAMM=0.
      DO 30 J=1,20
      DO 30 I=1,5
      ACOST(J,I)=DMATX(3,20)*CCOST(J,I)/3.65/SMATX(2,1)
   30 TAMM=TAMM+ACOST(J,I)
      TOPER=0.
      DO 40 J=1,20
      DO 40 I=1,5
      COSTO(J,I)=COSTO(J,I)/3.65/SMATX(2,1)
   40 TOPER=TOPER+COSTO(J,I)
      TOTAL=0.
      DO 50 J=1,20
      DO 50 I=1,5
      TCOST(J,I)=COSTO(J,I)+ACOST(J,I)
   50 TOTAL=TOTAL+TCOST(J,I)
      OMATX(1,20)=CENG
      OMATX(2,20)=CCR
      OMATX(3,20)=TCAP
      OMATX(4,20)=TAMM
      OMATX(5,20)=TOPER
      OMATX(6,20)=TOTAL
      RETURN
      END
```

PRINT OUTPUT

```
      SUBROUTINE PRINT
      INTEGER OS1,OS2
      COMMON SMATX(20,25),TMATX(20,25),DMATX(20,20),OMATX(20,20),IP(25),
     . INP,IO,IS1,IS2,OS1,OS2,N,IAERF,CCOST(20,5),COSTO(20,5),
     . ACOST(20,5),TCOST(20,5)
      WRITE(IO,10)
   10 FORMAT(1H1,//,55X,'STREAM CHARACTERISTICS',//,65X,'VOLUME FLOW, MI
     .LLIONS OF GALLONS PER DAY',  /,65X,'CONCENTRATIONS, MILLIGRAMS/LIT
     .ER',/)
      DO 30 I=1,25
      IF(SMATX(1,I)) 20,30,20
   20 WRITE(IO,40) SMATX(1,I)
      WRITE(IO,50) (SMATX(J,I),J=2,9)
      WRITE(IO,60)
      WRITE(IO,70) SMATX(16,I),(SMATX(J,I),J=11,15),SMATX(17,I),
     . SMATX(10,I)
   30 CONTINUE
   40 FORMAT(2X,1HS,F3.0,12X,1HC,9X,3HSOC,7X,4HSNBC,8X,3HSON,8X,3HSCP,
     .  8X,3HSFM,7X,4HSBOD,8X,3HSSS)
   50 FORMAT(13X,8F11.3)
   60 FORMAT(16X,3HALK,8X,3HDOC,7X,4HDNBC,9X,2HDN,9X,2HDP,8X,3HDFM,7X,
     .  4HDBOD,8X,3HTSS)
   70 FORMAT(13X,8F11.3//)
      WRITE(IO,80)
   80 FORMAT(1H1,//,45X,'PROCESS CHARACTERISTICS',//,55X,'CCOST = CAPITA
     .L COST, THOUSANDS OF DOLLARS', /,55X,'COSTO = OPERATING + MAINTENA
     .NCE COST, CENTS/1000 GAL.',/,55X,'ACOST = AMORTIZATION COST, CENTS
     ./1000 GAL.',/,55X,'TCOST = TOTAL TREATMENT COST, CENTS/1000 GAL.',
     .//)
      DO 1500 I=1,25
      IF(IP(I)) 90,1500,90
   90 KK=IP(I)
      GO TO (100,150,200,1500,1500,250,300,350,400,450,500,550),KK
  100 WRITE(IO,110) I,CCOST(I,1),COSTO(I,1),ACOST(I,1),TCOST(I,1),
     . DMATX(16,I)
  110 FORMAT(1X,1HP,I2,2X,'PRELIMINARY',42X,'CCOST',5X,'COSTO',5X,
     . 'ACOST',5X,'TCOST',5X,'ECF',/T7,'TREATMENT',44X,F7.2,3X,F7.2,3X,
     . F7.2,3X,F7.2,2X,F3.1,//)
      GO TO 1500
  150 WRITE(IO,160) I,DMATX(1,I),DMATX(2,I),OMATX(1,I),OMATX(2,I),
     . CCOST(I,1),COSTO(I,1),ACOST(I,1),TCOST(I,1),DMATX(16,I)
  160 FORMAT(1X,1HP,I2,2X,'PRIMARY',7X,'FRPS',6X,'URPS',6X,'GPS',7X,'AFS
     .',7X,'CCOST',5X,'COSTO',5X,'ACOST',5X,'TCOST',5X,'ECF' ,/,6X,'SETT
     .LER',11X,F5.3,2X,F5.0,5X,F6.1,6X,F6.3,2X,F7.2,3X,F7.2,3X,F7.2,3X,
     .F7.2,2X,F3.1,//)
      GO TO 1500
  200 WRITE(IO,210) I,OMATX(1,I),DMATX(1,I),DMATX(3,I),DMATX(4,I),
     . DMATX(5,I),CMATX(2,I),DMATX(6,I),DMATX(7,I),OMATX(3,I),CMATX(4,I)
  210 FORMAT(1X,1HP,I2,2X,'AERATOR',6X,'BOD2',6X,'BOD5',8X,'DEGC',6X,
     . 'CAER20',4X,'DO',8X,'DOSAT',5X,'AEFF20',4X,'URSS',6X,'XRSS',6X,
     . 'AFS',/,4X,'FINAL SETTLER',F9.1,5X,F4.1,6X,F3.0,7X,F5.3,4X,F3.0,
     . 7X,F4.1,6X,F5.3,5X,F5.2,5X,F6.4,4X,F5.2)
      WRITE(IO,220) DMATX(8,I),OMATX(5,I),OMATX(6,I),OMATX(7,I),
     . OMATX(8,I),DMATX(2,I),CMATX(9,I),OMATX(10,I),OMATX(11,I)
  220 FORMAT(T20,'GSS',7X,'CAER',6X,'CEDR',6X,'VAER',6X,'VNIT',6X,
     . 'MLSS',6X,'MLASS',5X,'MLBSS',5X,'MLNBSS',/T21,F5.0,5X,F5.3,5X,
     . F5.3,5X,F5.3,4X,F5.3,4X,F6.0,4X,F6.0,4X,F6.0,4X,F6.0)
```

```
      WRITE(IO,230) OMATX(12,I),OMATX(13,I),OMATX(14,I),OMATX(15,I),
     . OMATX(16,I),OMATX(17,I),OMATX(18,I),OMATX(19,I),OMATX(20,I)
  230 FORMAT(T20,'MLDSS',5X,'MLISS',5X,'FOOD',6X,'RTURN',5X,'CNIT',6X,
     . 'CKWH',6X,'AIRCFD',5X,'BSIZE',4X,'CFPGAL',/T21,F6.0,4X,F6.0,4X,
     . F5.1,6X,F5.3,4X,F5.3,5X,F5.3,4X,F10.0,2X,F6.0,3X,F4.2,//)
      WRITE(IO,235) OMATX(16,I),CCOST(I,1),COSTO(I,1),ACOST(I,1),
     . TCOST(I,1),OMATX(15,I),CCOST(I,2),COSTO(I,2),ACOST(I,2),
     . TCOST(I,2)
  235 FORMAT(T33,'ECF',7X,'CCOST',5X,'COSTO',5X,'ACOST',5X,'TCOST',/T20,
     . 'AERATOR',7X,F3.1,5X,F7.2,3X,F7.2,3X,F7.2,3X,F7.2,//T20,'BLOWER',
     . 8X,F3.1,5X,F7.2,3X,F7.2,3X,F7.2,3X,F7.2,/)
      WRITE(IO,240) OMATX(14,I),CCOST(I,3),COSTO(I,3),ACOST(I,3),
     . TCOST(I,3),OMATX(13,I),CCOST(I,4),COSTO(I,4),ACOST(I,4),
     . TCOST(I,4)
  240 FORMAT(20X,'SLUDGE',7X,F3.1,5X,F7.2,3X,F7.2,3X,F7.2,3X,F7.2,/,20X,
     . 'PUMPS',//,20X,'FINAL',8X,F3.1,5X,F7.2,3X,F7.2,3X,F7.2,3X,F7.2,
     . /,20X,'SETTLER',///)
      GO TO 1500
  250 WRITE(IO,260) I,OMATX(1,I),OMATX(2,I),OMATX(1,I),OMATX(2,I),
     . CCOST(I,1),COSTO(I,1),ACOST(I,1),TCOST(I,1),OMATX(16,I)
  260 FORMAT(1X,1HP,I2,2X,'DIGESTER',6X,'TD',8X,'TDIG',6X,'C1DIG',5X,
     . 'C2DIG',5X,'CCOST',5X,'COSTO',5X,'ACOST',5X,'TCOST',5X,'ECF',/,
     . 23X,F4.1,8X,F4.1,5X,F5.3,2X,F7.2,3X,F7.2,3X,F7.2,3X,F7.2,3X,
     . F7.2,2X,F3.1)
      WRITE(IO,270) OMATX(3,I),OMATX(4,I),OMATX(5,I)
  270 FORMAT(20X,'VDIG',6X,'CH4CFD',4X,'CO2CFD',/21X,F6.1,4X,F7.0,3X,
     . F7.0//)
      GO TO 1500
  300 WRITE(IO,310) I,OMATX(1,I),OMATX(2,I),OMATX(1,I),OMATX(2,I),
     . CCOST(I,1),COSTO(I,1),ACOST(I,1),TCOST(I,1),OMATX(16,I),
     . OMATX(3,I),OMATX(4,I),OMATX(5,I)
  310 FORMAT(1X,1HP,I2,2X,'VACUUM',7X,'VFL',7X,'TVF',7X,'CFECL3',4X,
     . 'FECL3',5X,'CCOST',5X,'COSTO',5X,'ACOST',5X,'TCOST',5X,'ECF',/T7,
     . 'FILTER',8X,F4.1,6X,F5.3,5X,F5.3,5X,F6.2,4X,F7.2,3X,F7.2,3X,F7.2,
     . 3X,F7.2,2X,F3.1,/T20,'WP',8X,'AVF',7X,'CCHEM',/T21,F4.1,6X,F6.1,
     . 4X,F7.0,//)
      GO TO 1500
  350 WRITE(IO,360) I,OMATX(1,I),OMATX(3,I),OMATX(4,I),OMATX(1,I),
     . CCOST(I,1),COSTO(I,1),ACOST(I,1),TCOST(I,1),OMATX(16,I)
  360 FORMAT(1X,1HP,I2,2X,'THICKENER',4X,'TRR',7X,'GTH',7X,'GSTH',6X,
     . 'ATHM',6X,'CCOST',5X,'COSTO',5X,'ACOST',5X,'TCOST',5X,'ECF',/T21,
     . F5.3,5X,F5.0,5X,F4.1,6X,F7.0,3X,F7.2,3X,F7.2,3X,F7.2,3X,F7.2,2X,
     . F3.1,//)
      GO TO 1500
  400 WRITE(IO,410) I,OMATX(1,I),OMATX(3,I),OMATX(4,I),OMATX(5,I),
     . CCOST(I,1),COSTO(I,1),ACOST(I,1),TCOST(I,1),OMATX(16,I),
     . OMATX(1,I)
  410 FORMAT(1X,1HP,I2,2X,'ELUTRIATE',5X,'ERR',7X,'WRE',7X,'GE',8X,
     . 'GES',7X,'CCOST',5X,'COSTO',5X,'ACOST',5X,'TCOST',5X,'ECF',/24X,
     . F5.3,5X,F3.1,5X,F4.0,7X,F4.1,4X,F7.2,3X,F7.2,3X,F7.2,3X,F7.2,
     . 2X,F3.1,/,20X,'AE',/,21X,F6.1,//)
      GO TO 1500
  450 WRITE(IO,460) I,OMATX(1,I),OMATX(1,I),CCOST(I,1),COSTO(I,1),
     . ACOST(I,1),TCOST(I,1),OMATX(16,I)
  460 FORMAT(1X,1HP,I2,2X,'SLUDGE',7X,'SBL',7X,'ASB',27X,'CCOST',5X,
     . 'COSTO',5X,'ACOST',5X,'TCOST',5X,'ECF',/6X,'BEDS',10X,F3.1,7X,
     . F7.0,23X,F7.2,3X,F7.2,3X,F7.2,3X,F7.2,2X,F3.1,//)
```

```
      GO TO 1500
  500 WRITE(IO,510) I,DMATX(1,I),DMATX(2,I),DMATX(5,I),DMATX(6,I),
     . DMATX(4,I),DMATX(3,I),DMATX(7,I),OMATX(1,I),DMATX(8,1),
     . CMATX(2,I),CMATX(3,I),CMATX(4,I)
  510 FORMAT(1X,1HP,I2,2X,'TRICKLING',7X,'BODOUT',4X,'DEGC',5X,'URSS',
     . 5X,'ERSS',5X,'SAREA',4X,'HQ',4X,'RECYCL',5X,'AFS',5X,'GSS',/,7X,
     . 'FILTER',9X,F5.1,5X,F4.0,4X,F5.2,4X,F6.4,4X,F4.1,4X,F4.1,4X,F4.1,
     . 4X,F5.2,3X,F5.0,/,4X,'FINAL SETTLER', 9X,'VOL',13X,'FAREA',7X,
     . 'DEPTH',/,22X,F12.3,4X,F12.3,4X,F7.2,//)
      WRITE(IO,520) DMATX(16,I),CCOST(I,1),COSTO(I,1),ACOST(I,1),
     . TCOST(I,1),DMATX(15,I),CCOST(I,2),COSTO(I,2),ACOST(I,2),
     . TCOST(I,2),DMATX(14,I),CCOST(I,3),COSTO(I,3),ACOST(I,3),
     . TCOST(I,3)
  520 FORMAT(T33,'ECF',7X,'CCOST',5X,'COSTO',5X,'ACOST',5X,'TCOST',
     . /T20,'FILTER',8X,F3.1,5X,F7.2,3X,F7.2,3X,F7.2,3X,F7.2,//T20,
     . 'FINAL', 9X,F3.1,5X,F7.2,3X,F7.2,3X,F7.2,3X,F7.2,/T20,'SETTLER',
     . //T20,'SLUDGE',8X,F3.1,5X,F7.2,3X,F7.2,3X,F7.2,3X,F7.2,/
     . T20,'PUMPS',///)
      GO TO 1500
  550 WRITE(IO,560) I,DMATX(8,20),DMATX(1,I),DMATX(2,I),CCOST(I,1),
     . COSTO(I,1),ACOST(I,1),TCOST(I,1),DMATX(16,I)
  560 FORMAT(1X,1HP,I2,2X,'CHLORINATE',4X,'CCL2',6X,'DCL2',7X,'TCL2',
     . 15X,'CCOST',5X,'COSTO',5X,'ACOST',5X,'TCOST',5X,'ECF',/,24X,F5.2,
     . 3X,F5.2,3X,F5.2,16X,F7.2,3X,F7.2,3X,F7.2,3X,F7.2,2X,F3.1,//)
 1500 CONTINUE
      WRITE(IO,1600) DMATX(2,20),DMATX(3,20),OMATX(1,20),DMATX(4,20),
     . DMATX(5,20),DMATX(6,20),OMATX(2,20)
 1600 FORMAT(1H1,//////,49X'TOTAL  PLANT  COST',///,19X,'CCI',7X,'AF',
     . 8X,'ENG',7X,'CTRP',6X,'CTGO',6X,'CLAND',5X,'CCR',/,19X,F5.3,5X,
     . F6.4,4X,F5.3,5X,F5.3,5X,F5.3,5X,F5.3,5X,F4.2,//)
      WRITE(IO,1610) OMATX(3,20),OMATX(4,20),OMATX(5,20),OMATX(6,20)
 1610 FORMAT(19X,'TOTAL CAPITAL COST = ',F10.2,' THOUSANDS OF DOLLARS',
     . //,14X,'TOTAL AMORTIZATION COST = ',F7.2,' CENTS/ 1000 GALS.',//,
     . 21X,'TOTAL O + M CCST = ',F7.2,' CENTS/ 1000 GALS.',//,17X,
     . 'TOTAL TREATMENT COST = ',F7.2,' CENTS/ 1000 GALS.')
      RETURN
      END
```

FIGURE IV

INPUT DATA

K	N	PROCESS		IS1	IS2	OS1	OS2	III
0	7	1	PREL	1	0	3	0	2
1	0	4	MIX	3	9	20	0	1
0	1	2	PRSET	20	0	2	8	0
0	2	3	AERFS	2	0	5	7	0
0	0	5	SPLIT	5	0	24	17	0
0	0	4	MIX	7	8	10	0	0
0	3	8	THICK	10	0	12	11	0
0	4	6	DIG	12	0	13	0	0
0	5	9	ELUT	13	17	15	14	0
0	6	7	VACF	15	0	18	16	0
0	0	4	MIX	11	14	21	0	0
1	0	4	MIX	16	21	9	0	1
0	8	12	CHLOR	24	0	25	0	2
0	9	10	SBEDS	18	0	19	0	2
9	0	0		0	0	0	0	0

STREAM CHARACTERISTICS

VOLUME FLOW, MILLIONS OF GALLONS PER DAY
CONCENTRATIONS, MILLIGRAMS/LITER

S 1.	Q	SOC	SNBC	SON	SOP	SFM	SBOD	VSS
	10.000	105.000	30.000	10.000	2.000	30.000	140.200	223.600
	ALK	DOC	DNBC	DN	DP	DFM	DBOD	TSS
	250.000	43.000	11.000	19.100	4.000	500.000	59.840	253.600
S 2.	Q	SOC	SNBC	SON	SOP	SFM	SBOD	VSS
	10.276	53.324	15.403	5.142	1.007	15.313	70.956	113.787
	ALK	DOC	DNBC	DN	DP	DFM	DBOD	TSS
	265.470	42.438	11.000	23.376	4.845	500.000	58.789	141.300
S 3.	Q	SOC	SNBC	SON	SOP	SFM	SBOD	VSS
	10.000	105.000	30.000	10.000	2.000	30.000	140.200	223.600
	ALK	DOC	DNBC	DN	DP	DFM	DBOD	TSS
	250.000	43.000	11.000	19.100	4.000	500.000	59.840	253.600
S 5.	Q	SOC	SNBC	SON	SOP	SFM	SBOD	VSS
	10.113	9.044	4.046	1.494	0.090	3.173	10.045	21.526
	ALK	DOC	DNBC	DN	DP	DFM	DBOD	TSS
	265.470	12.582	11.000	21.309	5.417	500.000	2.958	24.700
S 7.	Q	SOC	SNBC	SON	SOP	SFM	SBOD	VSS
	0.163	2184.711	977.525	360.880	21.847	766.651	2426.548	5199.612
	ALK	DOC	DNBC	DN	DP	DFM	DBOD	TSS
	265.470	12.582	11.000	21.309	5.417	500.000	2.958	5966.262
S 8.	Q	SOC	SNBC	SON	SOP	SFM	SBOD	VSS
	0.012	42605.953	12307.224	4108.516	804.978	12235.300	56694.023	90916.203
	ALK	DOC	DNBC	DN	DP	DFM	DBOD	TSS
	265.470	42.438	11.000	23.376	4.845	500.000	58.789	112898.812
S 9.	Q	SOC	SNBC	SON	SOP	SFM	SBOD	VSS
	0.289	158.803	57.279	19.635	2.442	50.892	194.721	354.676
	ALK	DOC	DNBC	DN	DP	DFM	DBOD	TSS
	799.445	23.043	10.999	170.974	34.046	500.000	22.521	1271.049
S10.	Q	SOC	SNBC	SON	SOP	SFM	SBOD	VSS
	0.176	5134.269	1804.258	634.347	78.992	1603.524	6386.472	11454.392
	ALK	DOC	DNBC	DN	DP	DFM	DBOD	TSS
	265.470	14.760	11.000	21.460	5.375	500.000	7.032	13769.181
S11.	Q	SOC	SNBC	SON	SOP	SFM	SBOD	VSS
	0.137	328.283	115.363	40.559	5.050	102.528	408.349	732.390
	ALK	DOC	DNBC	DN	DP	DFM	DBOD	TSS
	265.470	14.760	11.000	21.460	5.375	500.000	7.032	880.397

S12.

Q	SOC	SNBC	SON	SOP	SFM	SBOD	VSS
0.038	22372.871	7862.160	2764.205	344.214	6987.448	27829.418	49913.164
ALK	DOC	DNBC	DN	DP	DFM	DBOD	TSS
265.470	14.760	11.000	21.460	5.375	500.000	7.032	60000.007

S13.

Q	SOC	SNBC	SON	SOP	SFM	SBOD	VSS
0.038	8082.650	7862.160	1008.399	125.571	6987.448	412.316	19236.703
ALK	DOC	DNBC	DN	DP	DFM	DBOD	TSS
4339.815	84.496	11.000	1162.734	224.018	500.000	137.438	26224.148

S14.

Q	SOC	SNBC	SON	SOP	SFM	SBOD	VSS
0.140	0.598	0.267	0.098	0.005	0.210	0.665	1.425
ALK	DOC	DNBC	DN	DP	DFM	DBOD	TSS
1284.056	30.560	11.000	306.665	60.067	500.000	36.578	1736.149

S15.

Q	SOC	SNBC	SON	SOP	SFM	SBOD	VSS
0.012	18492.843	17988.367	2307.185	287.303	15987.054	943.367	44012.953
ALK	DOC	DNBC	DN	DP	DFM	DBOD	TSS
1284.056	30.560	11.000	306.665	60.067	500.000	36.578	60000.007

S16.

Q	SOC	SNBC	SON	SOP	SFM	SBOD	VSS
0.010	61.642	59.961	7.690	0.957	53.290	3.144	146.709
ALK	DOC	DNBC	DN	DP	DFM	DBOD	TSS
1284.056	30.560	11.000	306.665	60.067	500.000	36.578	200.000

S17.

Q	SOC	SNBC	SON	SOP	SFM	SBOD	VSS
0.115	9.044	4.046	1.494	0.090	3.173	10.045	21.526
ALK	DOC	DNBC	DN	DP	DFM	DBOD	TSS
265.470	12.582	11.000	21.309	5.417	500.000	2.958	24.700

S18.

Q	SOC	SNBC	SON	SOP	SFM	SBOD	VSS
0.000	1960.726	1907.238	244.622	30.461	1695.047	100.021	4666.527
ALK	DOC	DNBC	DN	DP	DFM	DBOD	TSS
136.143	3.240	1.166	32.514	6.368	53.013	3.878	6361.575

S19.

Q	SOC	SNBC	SON	SOP	SFM	SBOD	VSS
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
ALK	DOC	DNBC	DN	DP	DFM	DBOD	TSS
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

S20.

Q	SOC	SNBC	SON	SOP	SFM	SBOD	VSS
10.289	106.514	30.768	10.271	2.012	30.588	141.735	227.290
ALK	DOC	DNBC	DN	DP	DFM	DBOD	TSS
265.470	42.438	11.000	23.376	4.845	500.000	58.789	282.247

S21.

Q	SOC	SNBC	SON	SOP	SFM	SBOD	VSS
0.278	162.613	57.173	20.103	2.500	50.798	202.233	362.830
ALK	DOC	DNBC	DN	DP	DFM	DBOD	TSS

	780.443	22.748	10.999	163.653	33.026	500.000	21.970	1313.046

S24.	Q	SOC	SNBC	SON	SOP	SFM	SBOD	VSS
	9.998	9.044	4.046	1.494	0.090	3.173	10.045	21.526
	ALK	DOC	DNBC	DN	DP	DFM	DBOD	TSS
	265.470	12.582	11.000	21.309	5.417	500.000	2.958	24.700

S25.	Q	SOC	SNBC	SON	SOP	SFM	SBOD	VSS
	9.998	9.044	4.046	1.494	0.090	3.173	10.045	21.526
	ALK	DOC	DNBC	DN	DP	DFM	DBOD	TSS
	265.470	12.582	11.000	21.309	5.417	500.000	2.958	24.700

PROCESS CHARACTERISTICS

CCOST = CAPITAL COST, THOUSANDS OF DOLLARS
COSTO = OPERATING + MAINTENANCE COST, CENTS/1000 GAL.
ACOST = AMORTIZATION COST, CENTS/1000 GAL.
TCOST = TOTAL TREATMENT COST, CENTS/1000 GAL.

P 1 PRIMARY SETTLER

FRPS	URPS	GPS	APS	CCOST	COSTO	ACOST	TCOST	ECF
0.500	400.	1375.2	14.964	314.82	0.67	0.57	1.25	2.0

P 2 AERATOR FINAL SETTLER

BOD2	BOD5	DEGC	CAER20	DO	DOSAT	AEFF20	URSS	XRSS	AFS
129.7	13.0	20.	1.000	1.	10.7	0.050	3.00	0.0124	15.10
GSS	**CAER**	**CEDR**	**VAER**	**VNIT**	**MLSS**	**MLASS**	**MLBSS**	**MLNBSS**	
2000.	1.000	0.124	2.307	2.515	2000.	871.	264.	547.	
MLDSS	**MLISS**	**FOOD**	**RTURN**	**CNIT**	**CKWH**	**AIRCFD**	**BSIZE**	**CFPGAL**	
62.	255.	111.6	0.470	0.321	0.010	9539840.	9937.	0.92	

	ECF	CCOST	COSTO	ACOST	TCOST
AERATOR	1.2	677.63	1.23	1.24	2.47
BLOWER	1.5	104.42	0.52	0.19	0.71
SLUDGE PUMPS	2.0	22.04	0.00	0.04	0.04
FINAL SETTLER	2.0	294.81	0.00	0.54	0.54

P 3 THICKENER

TRR	GTH	GSTH	ATHM	CCOST	COSTO	ACOST	TCOST	ECF
0.950	750.	9.0	3369.	126.25	0.00	0.23	0.23	1.5

P 4 DIGESTER

TD	TDIG	C1DIG	C2DIG	CCOST	COSTO	ACOST	TCOST	ECF
15.0	33.0	0.260	854.98	274.35	0.33	0.50	0.84	2.0
VDIG	**CH4CFD**	**CO2CFD**						
154.1	89537.	47023.						

P 5 ELUTRIATE

ERR	WRE	GE	GES	CCOST	COSTO	ACOST	TCOST	ECF
0.760	3.0	800.	9.0	121.73	0.00	0.22	0.22	1.5
AE								
1399.0								

P 6 VACUUM FILTER

VFL	TVF	CFECL3	FECL3	CCOST	COSTO	ACOST	TCOST	ECF
4.9	0.238	0.080	7.81	240.04	0.43	0.44	0.87	1.0
WP	**AVF**	**CCHEM**						
70.5	390.5	14560.						

P 7 PRELIMINARY TREATMENT

CCOST	COSTO	ACOST	TCOST	ECF
94.12	0.27	0.17	0.44	1.0

P 8	CHLORINATE	CCL2	DCL2	TCL2	CCOST	COSTO	ACOST	TCOST	ECF
		0.08	8.00	30.00	55.69	0.53	0.10	0.63	1.0

P 9	SLUDGE BEDS	SBL	ASB		CCOST	COSTO	ACOST	TCOST	ECF
		4.4	0.		0.00	0.00	0.00	0.00	1.0

TOTAL PLANT COST

CCI	AF	ENG	CTRP	CTGO	CLAND	CCR
1.130	0.0670	0.073	0.100	0.150	0.020	1.34

TOTAL CAPITAL COST = 2342.91 THOUSANDS OF DOLLARS

TOTAL AMORTIZATION COST = 4.30 CENTS/ 1000 GALS.

TOTAL O + M COST = 4.01 CENTS/ 1000 GALS.

TOTAL TREATMENT COST = 8.31 CENTS/ 1000 GALS.

ADVANCED WASTE TREATMENT RESEARCH LABORATORY

EXECUTIVE DIGITAL COMPUTER PROGRAM FOR PRELIMINARY DESIGN OF WASTEWATER TREATMENT SYSTEMS

SHEET 1

NIS	NN(1)	NN(2)	NN(3)	NN(4)	NN(5)	NN(6)	NN(7)	NN(8)	NN(9)	NN(10)	EPS

INPUT STREAM VECTORS

Q	SOC	SNBC	SON	SOP	SFM	SBOD	VSS
TSS	DOC	DNBC	DN	DP	DFM	ALK	DBOD

Q	SOC	SNBC	SON	SOP	SFM	SBOD	VSS
TSS	DOC	DNBC	DN	DP	DFM	ALK	DBOD

Q	SOC	SNBC	SON	SOP	SFM	SBOD	VSS
TSS	DOC	DNBC	DN	DP	DFM	ALK	DBOD

COST CONSTANTS

CKWH	CCI	AF	CTRP	CTOO	CLAND	CFECL3	CCL2

FIGURE V

ADVANCED WASTE TREATMENT RESEARCH LABORATORY
EXECUTIVE DIGITAL COMPUTER PROGRAM FOR PRELIMINARY DESIGN OF WASTEWATER TREATMENT SYSTEMS

SHEET 2